metal finishing

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Vol. 7 No. 77 (New series) MAY, 1961

Hellermann introduce a revolutionary new combined immersion degreasing and phosphating process—

fospray

No degreasing prior to spray phosphating

Forms zinc phosphate coating

Spray tunnels need only be half the length necessary with conventional solutions

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For further information about fospray write to Hellermann Ltd., Gatwick Road, Crawley, Sussex. Tel.: Crawley 2000.

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New additive NEOCHEL improves all cyanide copper and bronze baths

M&T NEOCHEL, a compatible liquid formulation, can be used in place of Rochelle salt and proprietary additives to the great advantage of the user.

Improved cathode efficiency . . . Baths containing Neochel plate faster than those containing other available additives.

Higher anode efficiency . . . even at current densities where other additives lose effect rapidly.

Minimizes effect of contaminants. With reducing and chelating action, NEOCHEL cuts effect of chromium contamination, promotes satisfactory deposits.

Cuts cyanide consumption. Higher anode efficiency slows cyanide decomposition and comsumption, thereby cutting a major bath upkeep cost.

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Smoother deposits . . . because anode corrosion is better; and troublesome hard water precipitates are reduced.

NEOCHEL outperforms anything available to date in improving bath operation. It means more efficient cyanide copper and bronze plating, contributes to better results and helps to curb operating problems. NEOCHEL is also responsible for the outstanding performance of the new M&T bright copper solution

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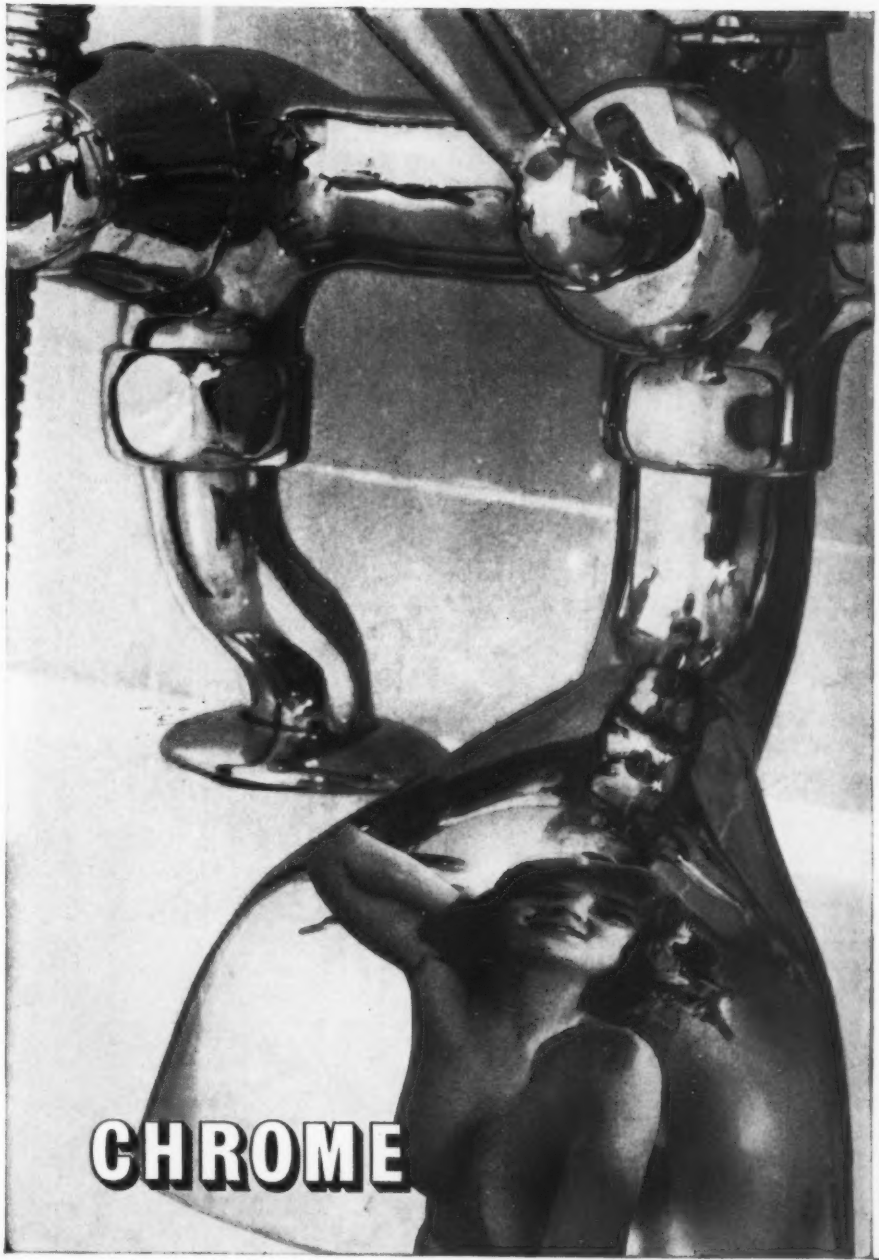

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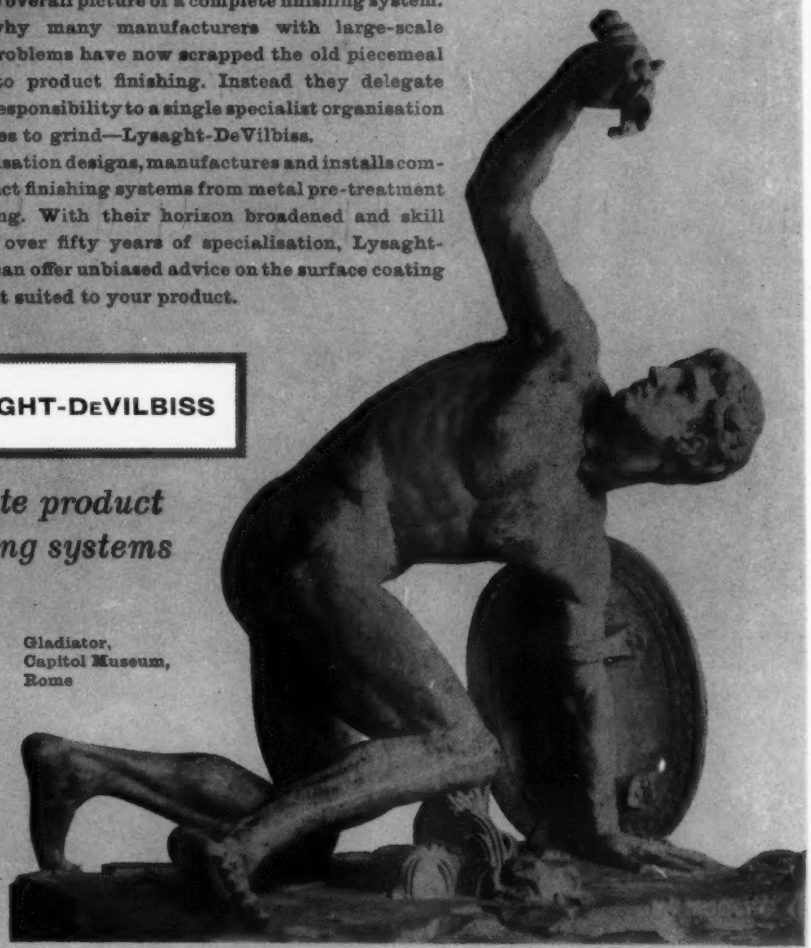
Where is the point ?

There is no point in taking on a dozen competing firms all pushing different pieces of finishing equipment. A mass of staff-consuming detail is involved tending to obscure the overall picture of a complete finishing system. That is why many manufacturers with large-scale finishing problems have now scrapped the old piecemeal approach to product finishing. Instead they delegate the whole responsibility to a single specialist organisation with no axes to grind—Lysaght-DeVilbiss.

This organisation designs, manufactures and installs complete product finishing systems from metal pre-treatment final stoving. With their horizon broadened and skill refined by over fifty years of specialisation, Lysaght-DeVilbiss can offer unbiased advice on the surface coating system best suited to your product.

LYSAGHT-DEVILBISS

complete product finishing systems



Gladiator, Capitol Museum, Rome

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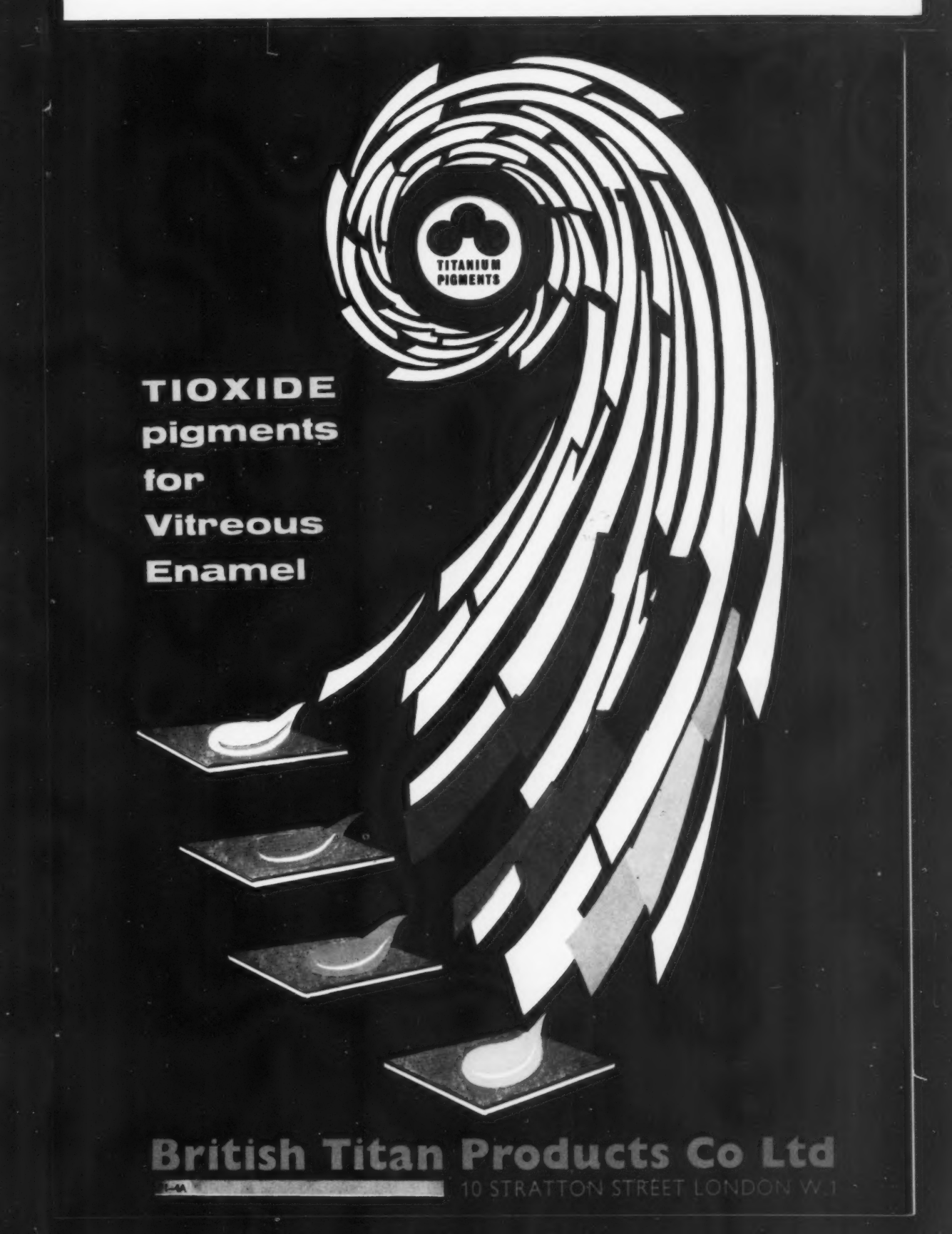
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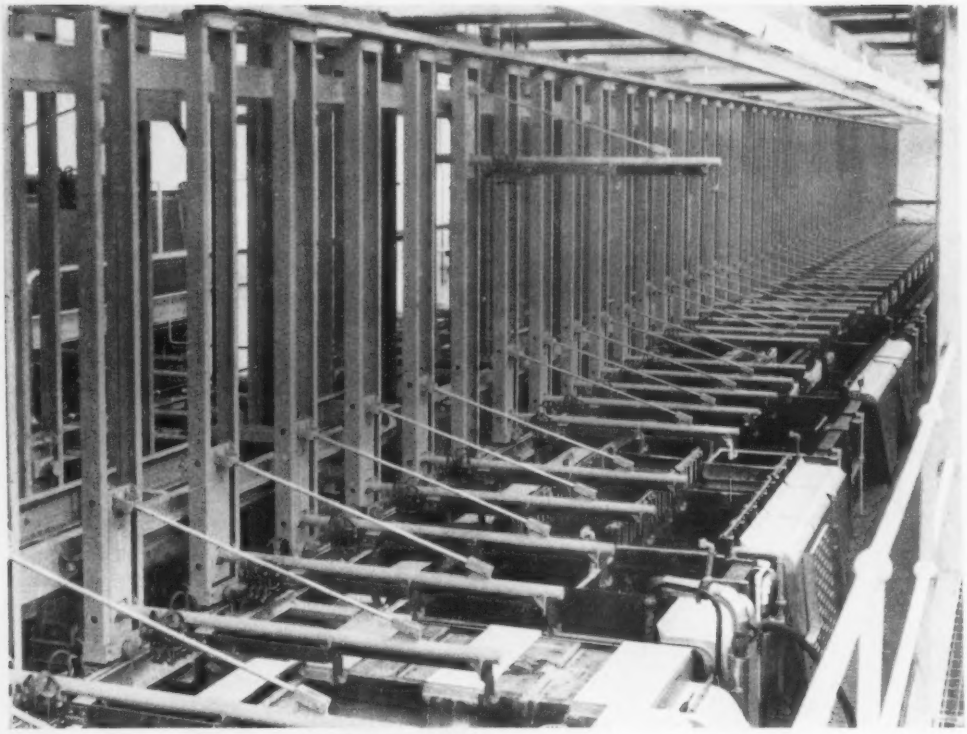

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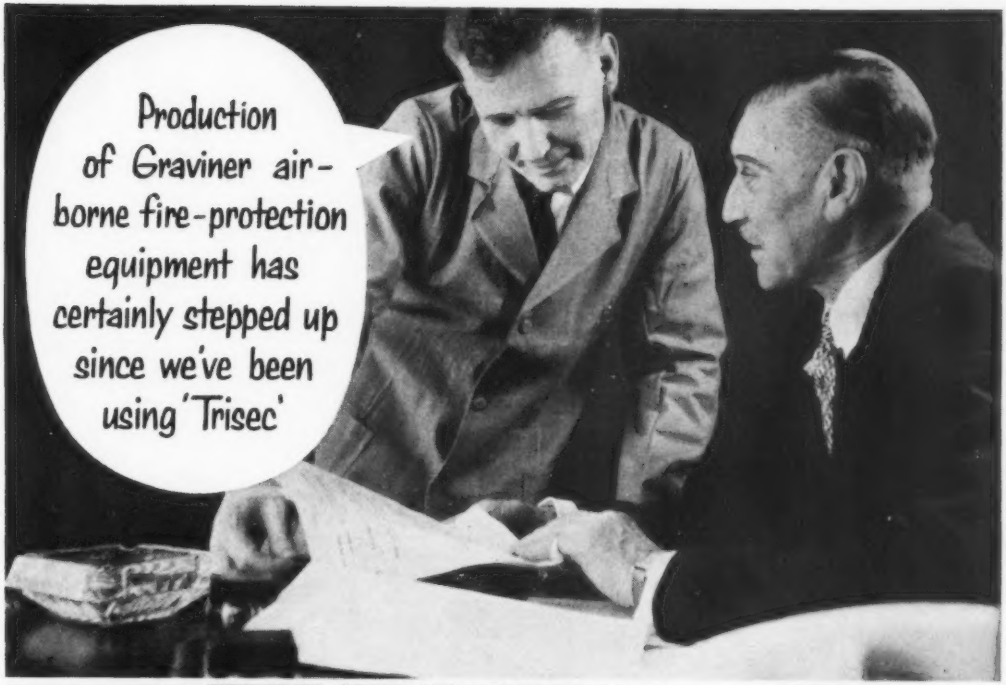

Our trouble at Wilkinson Sword Ltd., was this: after plating, the components took a long time to dry in sawdust or ovens — and still had to be polished to remove staining. It all cost too much in time, effort and money.

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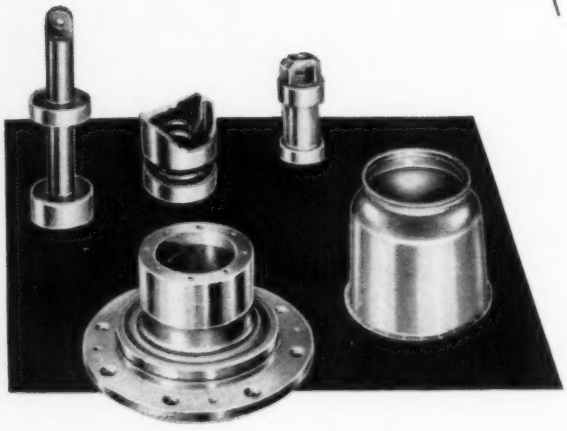
The ancients found their own techniques by a process of trial and error and a desire for greater ability.



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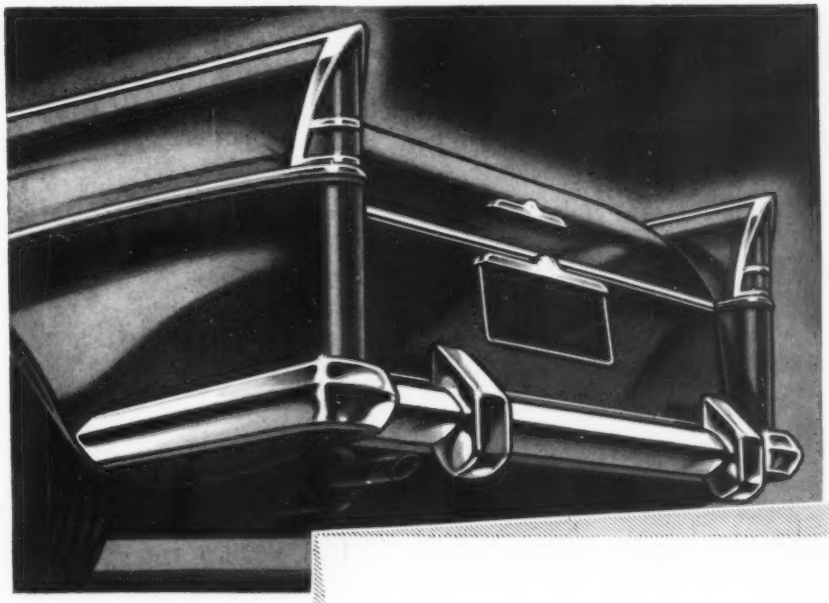

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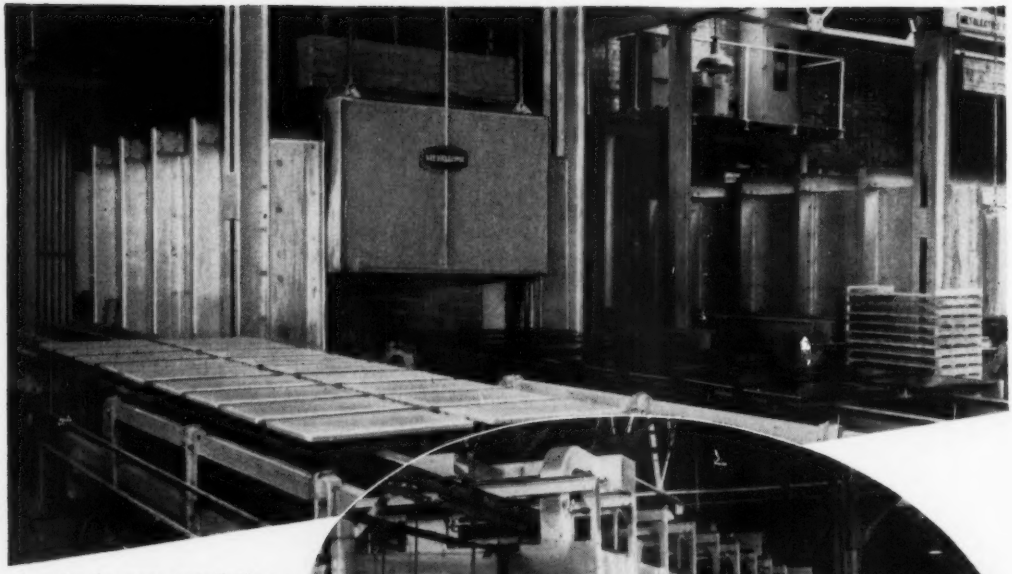
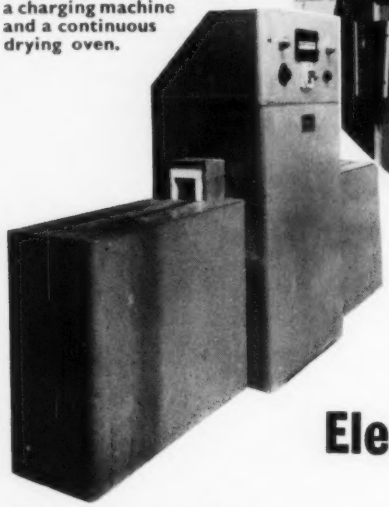


A twin furnace installation for fusing. The plant includes a charging machine and a continuous drying oven.



This furnace, rated at 10 kW, is used for badge enamelling.

U type fusing furnace for sheet iron cooker parts. Output 1500 sq. ft. (3000 lb.) per hour. Rating 650 kW.

Electric furnaces for fusing

Three examples of METALECTRIC batch and continuous furnaces serving the enamelling industry. All METALECTRIC designs are backed by 25 years experience in furnace building.

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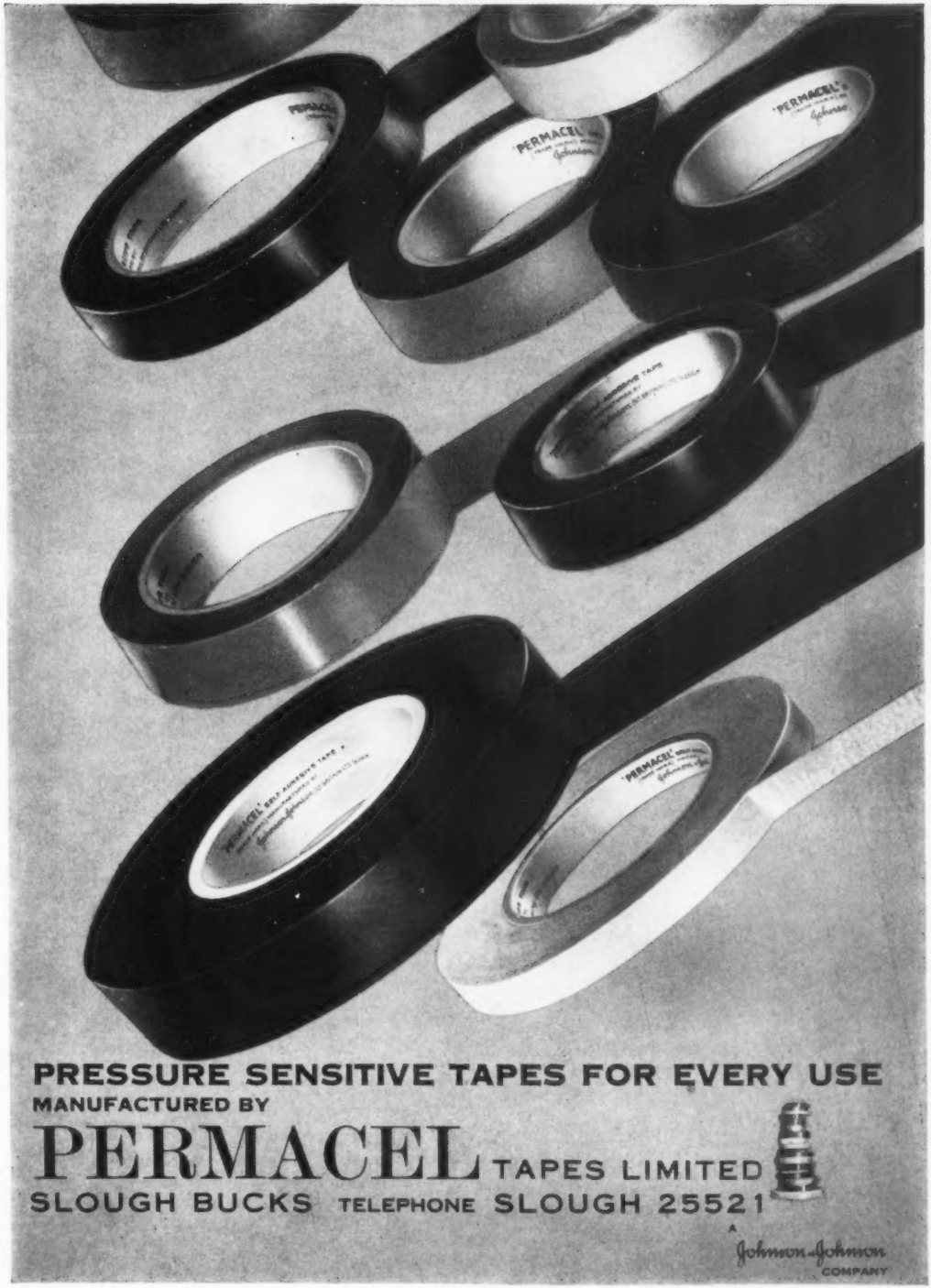
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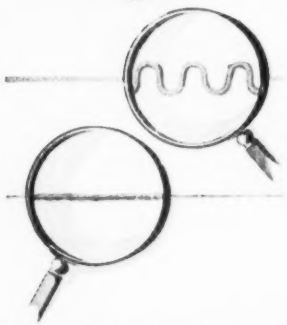

Magnified view of a cotton thread taken from " Tuff " material to show severe crimping.

Magnified view of a cotton thread.

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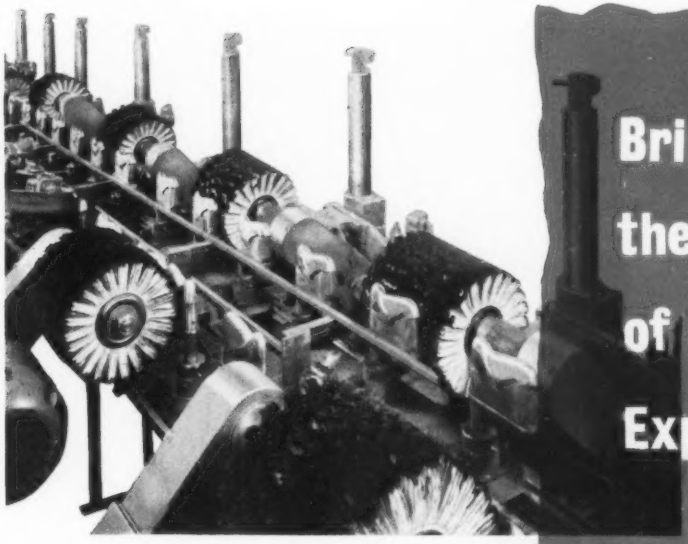

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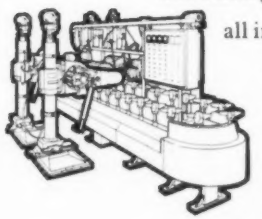

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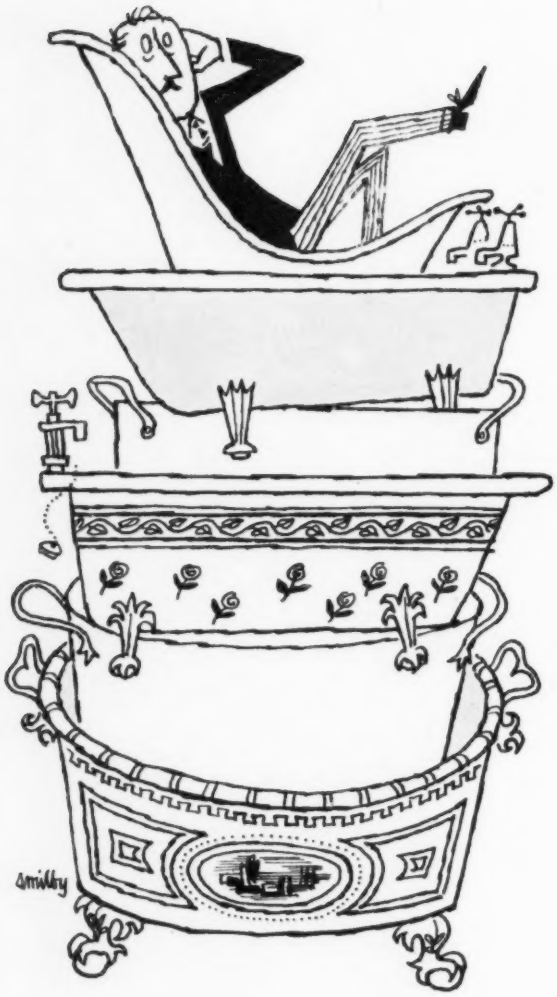

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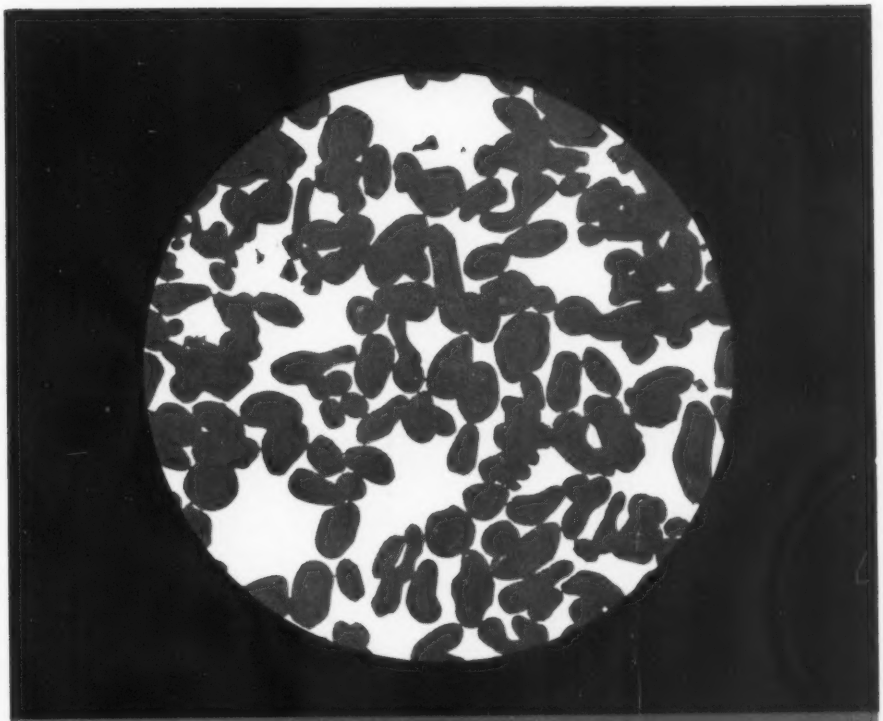

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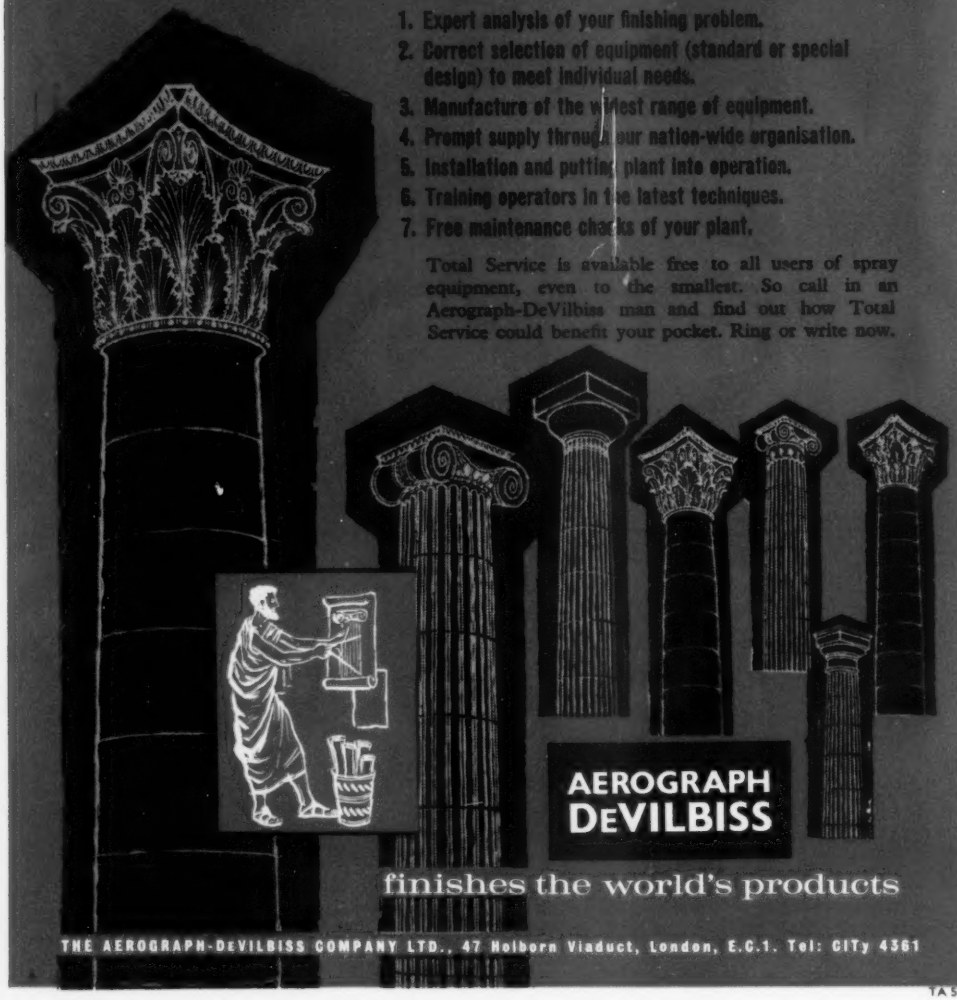

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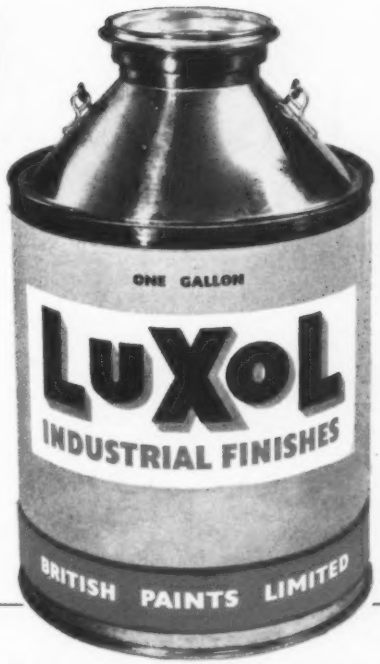

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If you are interested in barrel plating, a "Submatic" is worthwhile looking into straight away.

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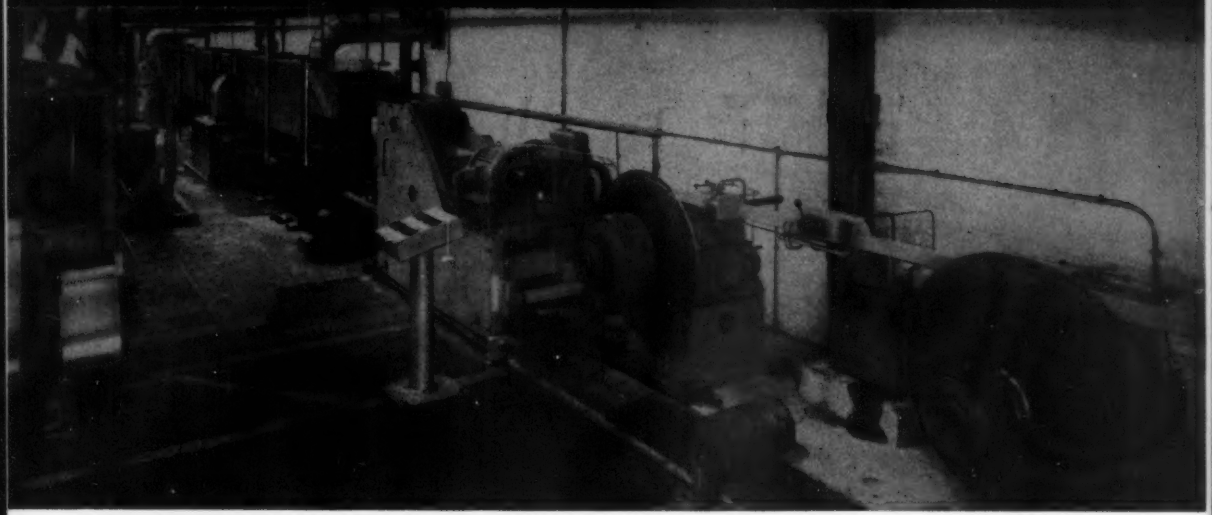

Photograph reproduced by courtesy of Messrs. Coated Strip Limited, Walsall.

Stordy specialise in the design and building of metal pre-treatment and finishing plant and this continuous strip coating installation demonstrates the combined skill of Stordy design, engineering and building experience applied to a specialised problem.

This continuous strip pre-treatment and finishing line illustrated is designed for strip speeds up to 70 feet per minute and strip widths up to 15" wide.

STORDY ENGINEERING LIMITED

CUMBRIA HOUSE · GOLDTHORN HILL · WOLVERHAMPTON

metal finishing journal

May, 1961 — AN INDUSTRIAL NEWSPAPERS PUBLICATION — Vol. 7, No. 77 (New Series)

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Published on the 15th day of each month by

INDUSTRIAL NEWSPAPERS
(Fuel and Metallurgical) Ltd.

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Subscription Terms :
Home and Overseas 24*s.* per annum prepayable
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Contents

PAGE

"A Brave Try" **167**

Talking Points **168**
" Platelayer "

A Survey of Non-electrolytic Chromate Treatments and Coatings **169**
W. T. Lee, F.R.I.C., A.Inst.S.P.

Metal Finishing Technology : A Students' Guide—8 **176**
A. Alexander

Testing Anodized Aluminium **181**
F. C. Porter, M.A., A.I.M.

Some Advantages of Automatic Plant Using Solvents for Degreasing **187**
J. Pickup

Finishing News Review **194**

Plant, Processes and Equipment **201**

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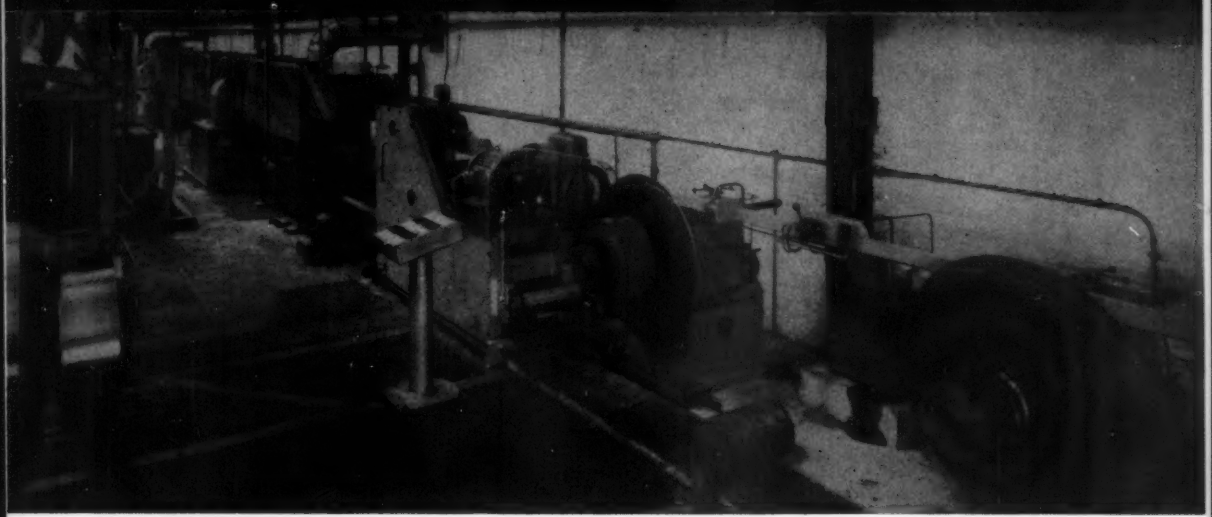
CONTINUOUS STRIP PRE-TREATMENT AND FINISHING PLANT



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Stordy specialise in the design and building of metal pre-treatment and finishing plant and this continuous strip coating installation demonstrates the combined skill of Stordy design, engineering and building experience applied to a specialised problem.

This continuous strip pre-treatment and finishing line illustrated is designed for strip speeds up to 70 feet per minute and strip widths up to 15" wide.

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CUMBRIA HOUSE · GOLDTHORN HILL · WOLVERHAMPTON

metal finishing journal

May, 1961 AN INDUSTRIAL NEWSPAPERS PUBLICATION Vol. 7, No. 77 (New Series)

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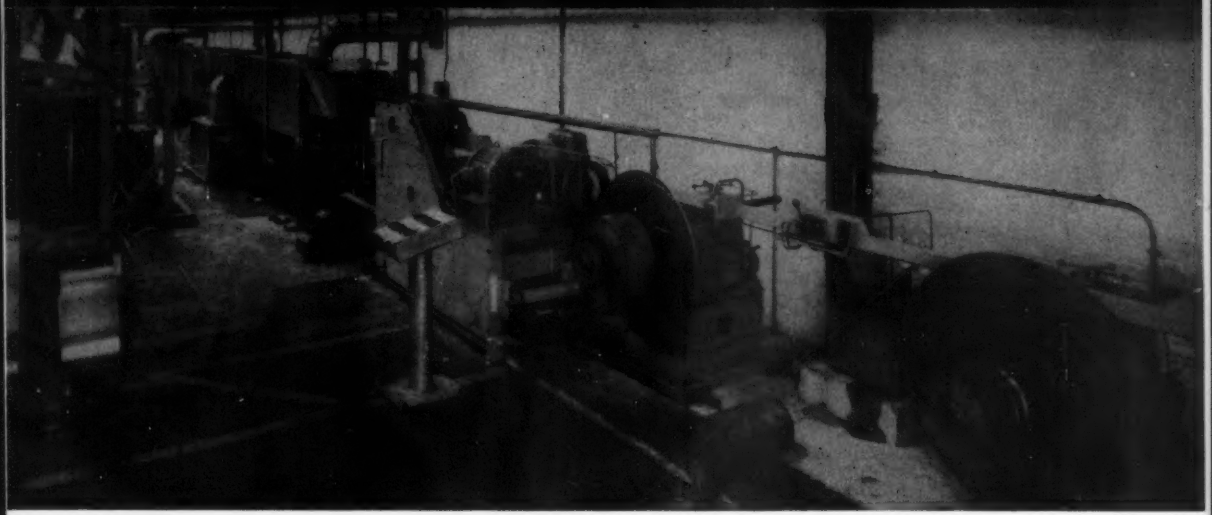

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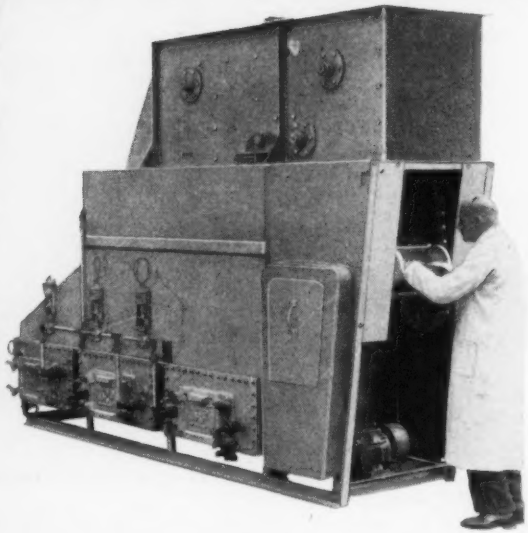

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A BRAVE TRY

"I ALWAYS say what I mean" said Alice "at least I mean what I say, which is the same thing." "It's not the same thing at all," said the Mad Hatter, who then proceeded to demonstrate by a series of examples just how different a thing it is. There are, of course, many people who from time to time do not mean what they say, but these are deliberately attempting to create a false impression from devious motives of their own.

In a very different category is the far greater number of people who fail in varying degrees to say what they mean.

The increasingly complex nature however, of our civilization and of the political, philosophical and scientific concepts which are evolving within it has given a fatal significance to the potential damage which can arise from misconceptions due to inadequacy of expression in the spoken or written word. While the greatest potential for evil lies in the domain of political demagogy, this is a field which lies outside our immediate terms of reference of this page, but we are concerned, and vitally, with the maintenance of high standards of communication in the broad sciences and technologies which are pertinent to finishing metal.

An appreciation of the difficulties inherent in maintaining clear and unequivocal channels of communication is implicit in the fact that the Department of Scientific and Industrial Research saw fit to organize last month a Conference devoted to a discussion of the "Problem of Communication between Science and Industry". This Conference was attended by some 250 delegates representing many large industrial organizations whose names are household words and several delegates from the various nationalized industries.

During the two days of the Conference nine papers were presented and discussed, and from a purely practical point of view it is perhaps unfortunate that the papers having been preprinted, so much time was devoted to their presentation that the time available for contributions from the body of the meeting had to be severely curtailed. The programme of papers ranged over a wide front discussing such media of communication as the press, exhibitions and conferences, films and television, while other papers reviewed the activities on information officers, teachers and information services. Many of the papers presented were well-written, thoughtful contributions which scored personal triumphs for their authors, although far greater skill was shown in analysing and assessing the scope of the problem than in proposing methods for its solution.

In as much as the Conference provided a platform upon which experts could publicly discuss the structure and operations of their specialized communications activities. it can be adjudged successful, but as a contribution to the solution of the very serious problem which it is generally admitted exists, it must be deemed to have failed. Virtually although those who were present were aware of the existence of the problem and are taking action to overcome it, so in this sense the sermon was preached largely to the converted. Furthermore, there was a great deal of sniping at dummy targets specially put up for the occasion and largely irrelevant to the main issue. Nevertheless, the whole venture can be acclaimed as a brave try, and it is to be hoped that a further attempt be made to reach a real solution of the problem by the organization of the meeting on somewhat different lines.

Talking Points

by " PLATELAYER "

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

HEADACHES TO COME

NATURE has endowed us with a fine range of metals, and they fulfil most of our requirements. Neverless, someone is always trying to play new tricks with them; converting them to powder and sticking the powder together again is now a well established practice. There are, however, several new developments of which we are likely to hear much more.

One of these is fibre metallurgy, in which a metal is converted to the fibrous form in much the same way as glass fibre is produced. The product can then be pressed and felted together to any required form by compacting and sintering, after which it may be rolled, machined, welded or subjected to a wide variety of other operations if desired. Fibre compacts of this type have the advantage of lightness, since they can look and feel like solid metal yet have a density as low as ten per cent. of that of the metal from which they are produced. They also are very strong and have a high vibration damping capacity.

Another technique is the production of foamed metals, one of the most important being a foamed 45 : 55 aluminium-magnesium alloy. This can be made either by adding a foaming agent such as zirconium hydride to the molten metal before it is cast, or by using a soluble salt filler, which is subsequently leached out, leaving a cellular metal with a weight of 12 to 70 lb. per cubic ft.

Although these products are still in their development stages, inevitably someone is going to want to plate them one day ! A degree of success has been achieved in dealing with the problem of plating articles made by powder metallurgy, but the new materials are likely to prove more intransigeant.

TO CLEAN OR NOT TO CLEAN

SOME months ago, I questioned in this column whether the oft-repeated advice to motorists to clean their chromium plate frequently to preserve its life is based on experimental evidence. If any such data exists, I have never heard of it.

Now a Danish correspondent in the Journal of the Institute of Metals has carried out tests on the tarnishing of silver contacts, which indicate that thorough cleaning of silver, particularly with organic solvents leaves it in a highly active state and particularly prone to discolour. Washing in a neutral soap solution, followed by rinsing with water is the best way to delay tarnishing by sulphides in the atmosphere.

Many chromium cleaners contain grease-dissolving or removing constituents, and it would not be surprising if they did more harm than good. The subject is one which has been strangely neglected by investigators.

SECOND THOUGHTS

I AM indebted to Galvanotechnik for the following plating story.

A man walked into a jobbing platers' office with a rather rusty motor-car hub cap, and asked for it to be re-chromed, adding that he would wait whilst it was being processed to save himself an extra journey. The Manager explained to the customer that as they were rather busy, it would be about two or three weeks before they could do the work, and that in any case it could not be done while he waited. The customer replied that, in that case, he was prepared to do it himself, and putting his hand in his pocket he produced a small bottle and asked if they could sell him a small amount of chrome for the purpose.

The Manager explained as patiently as he could, that there was a lot more to re-plating a hub cap than his visitor thought, and took him on a short trip around his factory, showing him the sequence of operations involved, from stripping and polishing to copper, nickel and chromium plating, inspection and packing. At the end of the tour, during which the customer looked pensive and made no comment, he picked up the hub cap from the Manager's desk and said : " Thinking the matter over, it would perhaps be better if I bought a new hub-cap."

PITFALL

THE Consumers' Association, publishers of " Which ? ", are conducting a poll on the subject of cars. In the course of a long questionnaire they invite critical comment on a list of features of members' existing cars, one of which is the " chromium." Having regard to the fact that the " chromium " on a good many cars might be anything from stainless steel to aluminium, the results, when they appear, should be treated with caution. To the average motorist, of course, it is all " chrome," which makes the collection of factual opinion on this subject a difficult matter.

A Survey of NON-ELECTROLYTIC CHROMATE TREATMENTS and COATINGS

By W. T. LEE, F.R.I.C., A.Inst.S.P. *

(One of a series of lectures, presented under the title of "Recent Developments in Non-Electrolytic Metal Finishing" at the Borough Polytechnic, London, and published by permission of the Principal).

NON-ELECTROLYTIC chromate conversion treatments are now widely used for inhibiting corrosion on a variety of metals and alloys, among which may be included aluminium, magnesium, copper, brass and bronze, tin, tin-zinc, zinc, cadmium and silver. These metals may themselves be base materials of commerce which require protection from corrosion, or alternatively electrodeposits, such as zinc and cadmium on steel, to protect some other metal or alloy. The coatings thus produced may be used either as the sole protective, or alternatively, as a base for organic finishing.

In some cases the coatings exhibit a direct decorative appeal, in others they may be conveniently dyed to yield an attractive variety of pastel and art shades eminently suitable for identification applications.

Uses of Chromate Coatings

Paint Bonding

Chromate conversion coatings show many advantages when used as a basis for subsequent organic finishing such as painting and lacquering. The reason for this is probably two-fold. First, because there is an improvement in the adhesion of the paint to the base metal, and, second, because the system shows a considerably improved service life — particularly after the organic film has suffered mechanical damage, or has, alternatively, proved to be porous or otherwise defective. The improvement in corrosion protection is due, not only to the physical barrier of the film itself, but to a self-healing property, which continues to protect even though scratches or abrasions have penetrated to the base metal itself. Furthermore, because of the amorphous, gel-like structure of the film, together with its relative thinness, little absorption of paint occurs, while the final, surface appearance of the paint film is free from the effects sometimes associated with heavier and crystalline-type bases.

Rubber Bonding

Conversion coatings have been successfully used in a number of bonding applications, particularly of rubber or organic adhesives to metal surfaces.

Welding, Soldering, etc.

Welding can normally be successfully carried out by employing slightly higher welding currents, or, alternatively, particularly for spot welding, localized chemical or physical removal of the coating may be desirable.

So far as the ease of soldering is concerned, this is chiefly dependent on the thickness of the film. The metallic bright to iridescent yellow films present no difficulty, but a chloride-based flux will be found necessary for the heavier, golden-yellow and olive drab films.

Electrical Resistance[1]

Chromate conversion coatings have a low electrical resistance, and a large number of copper, silver plated and aluminium electrical and electronic components are successfully protected by this means.

Decorative Applications

The metallic bright coatings have a decorative appeal, coupled to their enhanced corrosion protection which, for such components as internal car trim, cycle components, ice skates, domestic appliances, etc., finds widespread application. Similarly, the dyed coatings may have some limited decorative appeal, particularly on aluminium ; although black coatings on zinc and cadmium have application on matching instrument and optical components.

*Silvercrown Ltd.

Identification

The coatings may be successfully dyed and the colours used for coding or identification in storage or on assemblies.

Corrosion Protection

The conversion coatings have a wide application as corrosion protective films in their own right. Practically all the magnesium of commerce, whether wrought, sheet or cast, is protected by these means. Aluminium sheeting used for architectural purposes, zinc and cadmium plated components from corrosion by organic vapours during storage or in transit, silver plated contacts from sulphide tarnishing to mention but a few of a wide variety of uses. Protection is also conferred against finger-print staining, a corrosive hazard encountered in many industries.

Historical

Progress in chromate treatments is still relatively recent, for although they commenced some 30 to 35 years ago, it was the work of Anderson, resulting in the now famous Cronak Patent of 1936, which really focused attention on the protection by chromate ions leached from a protective film on zinc. Although full details of the process were not released until 1943,[2] the progress of World War II and its accompanying military requirements, followed by recurring localized military and political crises, material shortages and stockpiling, has maintained and stimulated interest in widening the scope and application of conversion treatments.

Chromating Solutions

Chromating baths usually consist of a solution of chromic acid and/or one of its soluble salts, to which is added one or more suitable activators such as sulphate, nitrate or chloride ions. Catalysts which either accelerate or retard the rate of film formation are now most common, together with a wide variety of proprietary additives which serve to alter the composition and physical properties of the film.

Application

In most cases the films are applied by simple immersion of the metal components into the chromating bath, frequently operated at room temperature, although sometimes, as in the case of aluminium and magnesium, temperatures up to, and including boiling may be necessary. Being non-electrolytic, the equipment used is essentially very simple, comprising only a suitable treatment tank, together with adequate swilling and drying arrangements.

Materials of construction vary widely with the composition of the solution and its operating temperature, but may be plastic, earthenware, mild steel, stainless steel, galvanized steel or aluminium, to mention but a few. Extra equipment would of course be necessary if the film required subsequent dyeing.

Probably the most important aspect of the after-treatment is the drying operation, for the film as formed is soft, gel-like and containing water of hydration. Too rapid or too severe drying will cause dehydration, leaving behind a film with considerably less corrosion resistance to humid and salt-spray conditions, although, somewhat strangely, harder and more resistant to acidic or alkaline environments. In many cases a maximum drying temperature would be 150°F., although in some cases, particularly with metallic bright coatings, boiling water may be employed. Drying ovens should of course be similarly regulated, while compressed air and warm circulating air are also frequently used for this purpose.

Pre-treatment is usually equally simple ; electro-deposits require only adequate rinsing before treatment. Base metals and alloys might at most require alkaline cleaning and acid activating prior to treatment. In some cases, where foreign metal inserts are included in a component, some form of stopping-off by wax, tape or lacquer might be required before treatment.

Other methods of application include spraying, which is particularly suitable for continuous treatment of strip, or on other mass-production lines ; or alternatively brush application which is extremely valuable for field service and repair work as well as in the treatment of components too large for immersion.

In the majority of cases treatment by spray is quicker and carried on at a lower temperature than by immersion, while the times and conditions of brush treatment generally involve longer process times, and perhaps altered formulations.

Characteristics of Chromate Films

It is widely believed that when a metal is immersed in a correctly formulated chromating solution, an oxidation-reduction reaction occurs, which ultimately results in the formation of a film containing, in various amounts, trivalent and hexavalent chromium compounds, water of hydration, and locked-in traces both of the metal being processed and the treatment solution itself. The trivalent chromium is thought to be present as a basic chromium chromate, $Cr_2O_3CrO_3.xH_2O$, as chromium hydroxide $Cr(OH)_3$, or as a mixture of both. This fraction is essentially insoluble, may be completely colourless or coloured, and is chiefly responsible for the hardness, physical toughness and flexibility of the film. The hexavalent portion of the film, responsible for the characteristic yellow colour, contributes little or nothing to its physical

characteristics. Its chief function lies in its solubility in damp, humid, environments, when it is slowly leached out, thus providing a continuous source of corrosion-inhibiting chromate ions, as little as 0.0001 gm. per l. of which is sufficient to offer protection to zinc. This leaching action is also primarily responsible for the self-healing action of chromate films, whereby protection is continued despite rupturing of the film. It might be imagined that the protective capacity of such a film would end when all the hexavalent chromium has been leached out, but this is not so, as Pocock[3] has demonstrated by the corrosion resistance of clear films containing little hexavalent chrome, and also by the continued resistance in salt-spray conditions of films leached of all colour during test.

As formed, the films are gelatinous and amorphous, and despite great advances in producing harder films of greater wet strength, are, nevertheless, comparatively soft and liable to mechanical damage. After rinsing and correct drying, however, the film becomes relatively tough and flexible, and any damage which occurs at this stage can be healed by the mechanism previously mentioned.

Whereas the early chromate films were all of the golden, iridescent variety, it is now possible to produce a wide range of coloured films varying from the metallic bright types to the deep golden-yellow and olive-drab shades. The variety of colours produced is usually a function of solution composition, time of treatment, process temperature and metal being chromated. The colours themselves would appear to be a function of the composition of the film and also its thickness. Thus, according to the amount of hexavalent chrome in the film, the variable composition of the trivalent portion and the degree of chemical etching or polishing taking place, will depend the colour of a film on electrodeposited zinc.

The thickness of the films can show considerable variation but will usually be in the range of 0.01 to 0.03 mil. with the colourless and faintly iridescent films being thinnest and the olive-drabs showing the greatest coating weight. The deeper coloured and heavier films will, of course, be most corrosion resistant, whether used alone or as a base for subsequent organic finishing. The lighter and clear coatings will have the greatest decorative appeal, which may be advantageous when used either alone, or possibly where only part of the component has to be painted ; choice is normally a compromise, depending on the service life expected, the corrosive environment and the decorative or matching appeal.

When dyeing is employed, the final colour obtained is a blend between the [11] colour of the dye and the colour of the film, and also depends on the quantity of dye absorbed and hence the film thickness. Deep art shades are produced by using deep dye shades and heavy golden to olive-drab coatings, while pastel shades are obtained by using lighter and brighter coloured dyes with lighter golden films.

While the chromate film is forming on the metal, the solution itself undergoes chemical change. There is a gradual increase in the trivalent chromium content of the solution, there will be a continuous increase in metallic contamination from the material processed, and possibly also a carry-in of contaminants from previous operations. In addition, the hexavalent chrome content and *p*H of the solution, normally used for its maintenance, will also alter and will, following chemical analysis and test, be replaced. Gradually, however, the other changes will render the solution unserviceable and it should be changed when optimum results are no longer obtainable with an analytically correct composition.

With chromating times of 5 to 90 seconds, between 0.01 to 0.1 mil. of metal may be removed and in cases where either the metal being removed is costly, or dimensional changes cannot be tolerated, this might also affect the choice of solution used. As might be expected, the *p*H of solutions vary considerably, and of course metal dissolution is greatest at the extremeties of the *p*H range. Zinc and cadmium, for instance, are dissolved more readily in the polishing-type dips, *p*H 0.0 to 1.5, than in the duller and heavier coating range solutions, *p*H 1.5 to 3.5.

ALUMINIUM AND ALUMINIUM ALLOYS

With correct pre-treatment and operating conditions, chromate-based treatments of one form or another may be successfully applied to all types of aluminium and aluminium alloys, whatever their form. The colours obtainable vary from metallic bright to iridescent, golden yellow, green-bronze, brown and grey, to almost black, depending on the process chosen, the treatment given and composition of the alloy. Although possibly the main value of chromate treatments lies in their application as a basis for paint bonding, many are also used as a finish in their own right as a protection against corrosion, and finger-print staining, whether or not the components must be subsequently joined by welding or used for electrical contact.

These types of treatment may be broadly subdivided into :—

1) The alkaline treatment which essentially reinforces the protective alumina coating.
2) The chromate-phosphate type films.
3) The newer type of acidic treatments which form true chromate films.

Alkaline Treatments (Chromate-Oxide Coatings)

a) *M.B.V. Process*[4]

This film, which varies in colour from metallic grey, bright to black, depending on the alloy processed, is produced by immersion for 3 to 6 minutes in a boiling solution of :—

Sodium Carbonate	— 3 to 8 oz. per gal.
Sodium Chromate	— 0.5 to 4 oz. per gal.

It consists essentially of chromium and aluminium oxides in various proportions. High copper alloys do not normally give good films by this process ; satisfactory films can be sealed by immersion in a hot solution of waterglass, or may be dyed, both by inorganic chemicals such as cobalt and copper nitrates, and also by certain organic dyestuffs.

E. W. Process[4]

This is essentially a modification of the previous process. A small quantity of sodium silicate is added to the solution and an almost transparent, but more corrosion-resistant film is obtained by ten minutes' immersion at, or near boiling point. A wider variety of alloys, including those of the Duralumin type may be treated in this solution, which has, however, a shorter life-time than the M.B.V. The films may be sealed by immersion in hot waterglass solution.

Pylumin Process[5]

There are many other processes which are similar in type to the M.B.V. process and the one most widely used in this country is the Pylumin process. The processing solution consists of :—

Sodium Carbonate	— 8 oz. per gal.
Sodium Chromate	— 3 oz. per gal.
Basic Chromium Carbonate	— 1 oz. per gal.

The chromium carbonate is replaceable by the carbonates of nickel, cobalt, manganese or titanium. Treatment consists of 3 to 5 minutes immersion in the boiling liquid, when a satin-grey or iridescent finish is formed. By increasing the concentrations quoted and including some caustic soda in the formulation, lower operating temperatures may be used. These solutions can be maintained over an extremely long life-time by simple chemical analysis, and also possess the advantage of being suitable for all aluminium alloys.

Alrok Process

A further alkaline treatment consists of 20 minutes' immersion in boiling solution of :—

Sodium Carbonate	— 3 oz. per gal.
Potassium Dichromate	— 1 oz. per gal.

Greenish-grey coatings are produced which have a more distinct yellow appearance after sealing in a hot dichromate solution.

Acid Treatments (Chromate-Phosphate Coatings)

Although several proprietary treatments are available — probably the best known is the Alochrom[6] range of processes. The solutions employed consist essentially of mixtures of chromates, phosphates and fluorides present in very carefully defined quantities, an example of which is :—

F/CrO_3 ratio	— 0.18 to 0.36
Fluoride	— 4 gm. per l.
Chromic Acid	— 17 gm. per l.
Phosphate	— 60 gm. per l.
*p*H	— 1.7 to 1.9

The coating produced, varying from iridescent yellow to olive green, consists of chromium and aluminium phosphates, water of hydration and traces of mixed metal fluorides. Application by immersion is normally carried out in the range 1-minute at 120°F. to 5-minutes at room temperature.

The process is also suitable for spray treatment, a typical time cycle for which would be 15 to 30 seconds at 65 to 90°F. During treatment a sludge of aluminium and chromium fluorides and chromium phosphate is formed and should be removed when necessary by decantation. The solution is controlled by chemical analysis.

Acid Chromate Treatments

In the last few years, processes based on acidified chromate-fluoride solutions have gained steadily in prominence. The coatings produced, normally 0.000005 in. to 0.00002 in. thick, vary in colour from metallic bright to deep, golden yellow and brown. They are believed to consist essentially of trivalent and hexavalent chromium compounds as well as some aluminium and fluoride ions. These coatings can be applied to practically all aluminium-based alloys by means of spray, immersion or brush.

One typical process, *i.e.*:—Kenvert No. 40[11] is operated at *p*H 1.6 and at a temperature between 90 to 120°F. Immersion is from 30 seconds to 4 minutes, during which time the coating changes from colourless to deep golden-bronze. As with most chromate conversion coatings, the corrosion resistance increases with increasing depth of colour, or, in other words, thickness.

The solution is normally controlled by titration of chrome content and also *p*H. If the *p*H of the solution is too high, a grey film, devoid of hexavalent chrome will be produced ; while too low a *p*H prevents formation of the coating.

When maximum corrosion protection is required, the final hot rinse should not exceed 150°F., prolonged immersion in boiling water will completely bleach the film.

For identification purposes the chromate coating

may be dyed a wide variety of colours, or otherwise forms an excellent base for subsequent painting. As a finish in its own right, it has found wide application both in the so-called "architectural" green shades and also in electronic applications where freedom from colour might be a desirable property.

The chief merit of all three types of coating is of course that they provide the metal processed with protection from corrosion. Compared to anodizing, the application is extremely economical, while pre-and after treatments are simple and un-demanding. Many have the advantage of being applied by brushing or spraying, thus enabling field work, or continuous treatment to be carried out on a scale considered impossible for electrolytic treatment. Moreover, components with base metal inserts, blind holes or even tubular components themselves may be treated. The solutions are easy to control and operate during their service life, and equipment is essentially confined to the process tanks, with, on occasions, suitable heating facilities.

Physically, these coatings are usually softer and more flexible than anodized coatings which may be advantageous if the component is subsequently subjected to any deformation after treatment. Anodic coatings on the other hand, are thicker, harder, more wear-resistant and corrosion-resistant, and may be more permanently and decoratively dyed than conversion coatings.

Regarding the three types of chromate treatments discussed, the chromate/fluoride type appears to be gaining steadily at the expense of the reinforced oxide type ; although as some workers have demonstrated, much depends on the ultimate purpose of the coating as well as the type of installation envisaged.

MAGNESIUM AND MAGNESIUM ALLOYS

One of the most widely used treatments for magnesium is the so-called Dow No. 1 Pickle,[7] which produces coatings varying from light grey to yellow brown in colour. The colour of the film depends both on the composition of the solution and also of the alloy treated. There are actually two versions of this process, formulated as follows :—

a) Sodium Dichromate — 30 oz. per gal.
Nitric Acid — 25 to 50 oz. per gal.
and

b) Sodium Dichromate — 30 oz. per gal.
Nitric Acid — 25 to 30 oz. per gal.
Sodium Fluoride — 2.5 oz. per gal.

Ammonium and potassium fluorides can be equally well used. The first version is used for wrought alloys which are normally processed for 30 seconds to 2 minutes at 70 to 90°F. After a further 5 seconds' drainage time, the components are thoroughly rinsed and dried. This solution can also be applied by brushing, to components too large for immersion and to others actually on site. Although steel or brass inserts do not prove harmful to the solution, they are etched by it and if this is undesirable, must be stopped off. The second solution is used for cast alloys which are again treated for 30 seconds to 2 minutes at 70 to 90°F. The addition of the alkali fluoride is necessary to minimize the chance of forming powdery grey films, which are pyrophoric and thus constitute a fire hazard as well as being useless for service. Powdery brown films may also be encountered ; these, however, are not pyrophoric and are usually produced from solutions of incorrect composition, or otherwise by faulty operating conditions. The solution itself does deteriorate in service and after several replenishments is finally disposed of and re-made.

A further treatment, the Dow No. 7[7] claims superior results to the No. 1 Pickle. This solution comprises :—

Sodium Dichromate — 20 to 30 oz. per gal.
Calcium or Magnesium Fluoride — ½ oz. per gal.

Treatment is by immersion in the boiling solution for 30 minutes and the finish obtained varies from a light- to dark-brown coloured film. This process is superior to the former in that almost all alloys can be treated, and that because of the more moderate *p*H, 4.0 to 5.5., dimensional changes are negligible, which allows the treatment of machined components.

This solution has a long lifetime and is adjusted by chemical determination of the dichromate content and *p*H. Unsatisfactory deposits may be obtained on high-manganese alloys, or improperly prepared metal, from an improperly controlled solution or because of contact between work and the vat.

The two processes are sometimes employed, in the order described, as a two-stage process, but the dimensional changes occurring in the first stage preclude the treatment on machined parts.

A cold solution which has found favour in this country is the M.E.L.[8] chrome-manganese bath which consists of :—

Sodium Dichromate — 16 oz. per gal.
Manganese Sulphate — 8 oz. per gal.
Magnesium Sulphate — 12 oz. per gal.
Wetting Agent as required.

The *p*H of the solution may be varied from 4.0 to 6.0 and heating may be employed to reduce the time of treatment which varies from two hours at room temperature to only 5 minutes at boiling point. The film varies in colour from very dark

grey to glossy black. The solution is simple to control and operate and can also be used in a variety of tanks, plastic, steel, galvanized etc., depending on temperature. A further process which has achieved commercial success in the country is the R.A.E. process which produces a hard and durable grey black film on the metal. The composition of this solution is :—

Ammonium Dichromate	— 2½ oz. per gal.
Potassium Dichromate	— 2½ oz. per gal.
Ammonium Sulphate	— 5 oz. per gal.

with the *p*H adjusted to between 5.9 to 6.1 by an addition of 10 to 20 ml. per gal. ammonia.

Treatment consists of 30 minutes' immersion in the boiling solution.

The disadvantage of this solution is that the composition is very important, particularly the chromic-acid : sulphate ratio, while the chloride content must also be kept very low. The *p*H limit is also rather narrow, and the ammonia is rapidly lost both because of the high operating temperature and also by chemical action.

A further process is the Tridur Mg process[9], which when operated at *p*H 1 to 1.3 producesin 30 to 90 seconds a golden-brown chromate film at room temperature. This process is analagous to the acidic treatments on aluminium and because of its simplicity, and application may gain further in popularity. It can be applied by spray as well as immersion and is thus satisfactory for mass production purposes.

Copper, Brass and Bronze

On these materials the colours normally obtainable vary from metallic bright to yellow brown. They may be produced from a variety of solutions based on chromic acid to which is added other mineral acids and proprietary additives, formulation chiefly depending on the composition of the metal to be treated. These baths have several advantages over conventional acid treatments, thus :—

1) They are essentially non-fuming and dispense with the need for fume extraction.
2) A passive film is formed which subsequently inhibits corrosion and surface tarnishing.
3) The rate of attack on the metal is more carefully controlled and brighter and more uniform results are obtainable over a wider range of conditions.

Treatment times in such solutions vary from 10 to 60 seconds at temperatures varying from room to 140°F. As a general rule, maximum brightness is obtainable, with higher concentration baths used at higher temperatures, with maximum passivation the reverse. As the concentration may vary from 3 to 30 per cent., the economics involved in using higher temperatures and concentrations is of obvious importance and optimum rather than maximum results should be aimed for.

Similarly, if the work should require preliminary pickling, a less expensive pickle could be employed, prior to chromating. If the work is to be painted, or left with the chromate film as a sole protection, the only after treatment required is the necessary swilling and drying. If, however, the work must be electroplated, it is first necessary to destroy the passive film, and this is best accomplished by dipping in dilute sulphuric acid. Great care should also be taken that none of this acid dip is carried into, *e.g.* a bright nickel plating solution, as this could eventually cause irreparable harm.

Other major uses of chromate treatments in this field are the dichromate-based rinses following copper, brass or bronze plating in cyanide-based electrolytes, and also a variety of dichromate based pickles for such alloys as nickel silver and beryllium copper.

Tin and Tin-Zinc

The treatment most widely used for the protection of electrodeposited and hot-dipped tin coatings is that recommended by the Tin Research Institute. This process involves immersion for 3 to 5 seconds at a temperature of 195 to 205°F., in a solution comprising :—

Sodium Chromate	— ½ oz. per gal.
Caustic Soda	— 3 oz. per gal.
Wetting agent	— trace

The film so formed is colourless, and after the usual careful swilling and drying forms a satisfactory protection, not only against humidity, but also against stains caused by heating or contact with certain foodstuffs.

Other versions of this solution containing mixtures of dichromates with caustic soda and condensed phosphates have been proposed for rather heavier films.

These solutions, with a *p*H of approx. 12.5, cause no attack of the base metal and are thus particularly attractive because of this. Tin-zinc may be protected[10] by immersing the deposit in a 2 per cent. chromic acid solution for period of 5 to 15 secs. at 120 to 180°F., the film so formed being colourless if a sulphate-free grade of chromic acid is used. A slightly yellowish colouration is obtainable in the presence of certain anions, particularly sulphate.

An alternative treatment immersion at room temperature in a solution comprising :—

Sodium Dichromate	— 10 gm. per l.
Sulphuric Acid	— 0.33 gm. per l.

Zinc and Cadmium

As has been previously mentioned, the Cronak process for the passivation of Zinc was the true commencement of all modern chromating pro-

cesses. The solution chiefly used in this country comprises :—

Sodium Dichromate	— 200 gm. per l.
Sulphuric Acid	— 6.6. ml. per l.

It is of course the solution on which the well-known D.T.D. 923 Specification is based, and until the last year or two has been used almost exclusively.

With a correctly balanced solution, treatment time can be varied in the range 5 to 10 seconds. The colour of the film produced is iridescent green or yellow-green — over-treatment producing a non-adherent brown film. The film has good protective qualities and to pass Specification must be capable of protecting zinc from its white corrosion products during a test comprising exposure for two 16-hour cycles at 55 C. and minimum 95 per cent. Relative Humidity followed by cooling to 30°C. Some of the weaknesses of this process, however, are :—

1) The very narrow time range for successful treatment, which is very much at the discretion of the operator.
2) The film is soft when wet and makes any form of bulk treatment dangerous.
3) The time factor prevents barrel-plated work being chromated actually in the barrel.
4) Difficulty of obtaining uniform results on automatic plants where, in spite of sub-lift mechanisms, the components at the bottom of a jig would be immersed for a longer period than those at the top. The transfer time is an additional drawback.
5) The rate of metal removal could be somewhat high.
6) The coating is unsuitable for many applications where decorative appeal or colour matching is required.

The first steps taken to obviate some of these difficulties lay in two directions. The first was the development of additives to the solution, which were able to slow down the rate of film formation so that more flexible operating conditions became possible. The second lay in the development of a more decorative finish by means of a two-stage process consisting of a combined polishing/chromating treatment in a solution based chiefly on chromic acid with additions of nitric and/or sulphuric acids, followed by a leaching treatment carried out in one of several different weakly alkaline solutions, or alternatively, in dilute phosphoric acid. This second stage essentially leached from the film most of the hexavalent chromium, leaving an almost colourless film of trivalent chromium which had good physical properties and conferred a high degree of protection in more acidic or alkaline conditions.

In addition to chromating some degree of chemical polishing also occurred, so that the finished result was usually of enhanced appearance, either to the electro-deposit itself or the electrodeposit brightened in nitric acid. The film before leaching was of a fairly iridescent appearance, itself quite attractive and containing hexavalent chromium so, that if warranted, the leach could be left out and the greater protection thus obtained. An example of this type of process is that covered by Specification D.T.D. 900/4299.

This enlargement to the original dichromate/sulphuric acid bath for many years covered gaps in the procedure, but were themselves subject to disadvantages. Thus, the rate of metal removal was rather high if a treatment time of 5 to 10 seconds was exceeded, so that although the film produced would have been satisfactory, it would have proved too costly for either barrel or automatic plants. Added to this, the fairly concentrated solutions employed led to difficulties of waste disposal and handling while in some cases the extra operation, *i.e.* leaching, never became acceptable.

More recently, work has been directed towards producing a considerable number of solutions, all with particular, but slightly different properties, so that a ready choice may be made. Thus, treatment times have been decelerated to as long as a 90-second immersion, without too much removal of metal.

One individual process (Kenvert 17A)[11] can, by only a very simple adjustment, be used over an immersion range of 5 to 50 seconds, both without unduly affecting the appearance, nor yet removing much more metal. The finish obtained is clear, bright, of attractive chrome-like appearance and sound protective quality ; this being achieved as a one-stage treatment in extremely dilute solution.

The use of more dilute baths is, in fact, a feature of modern chromating practice, effecting considerable monetary saving, as well as being easier to handle and subsequently destroy. They are also invariably maintained during production by simple analytical checks, and where the through-put justifies, can be readily discarded and rapidly remade. A further feature is the wide variety of coloured films which can be consistently produced by one-dip treatments, thus, for instance, on electrodeposited zinc, metallic bright, iridescent green and yellow, golden yellow, green-bronze and olive-drab, and similarly for Cadmium plate. The composition of the films is of course different, as also their thickness, and because of this, there will be a difference in their protective value, typical values of which are reported herewith :—

Clear Metallic	— 24 to 100 hours.
Iridescent	— 100 to 120 hours.
Yellow-green bronze	— 100 to 200 hours.
Olive-drab	— 100 to 500 hours.

(*Continued in page* 193)

Metal Finishing Technology — A Students' Guide: 8

An Introduction to the Examination Syllabus in Metal Finishing of the City and Guilds of London Institute

Compiled by A. ALEXANDER

INTERNAL MECHANISM OF AN ELECTROLYTIC CELL

IN the foregoing an attempt has been made to present a picture of what happens when an electric current is passed through a plating solution. Since it is extremely important that the student should be able to form the picture in his mind, it is proposed now to consider the actual mechanism of the current passing from one metal electrode to another suspended in an electrolyte. For simplicity, two sheets of nickel will be considered, suspended in a solution of nickel sulphate.

As previously mentioned, metals are composed of atoms, each containing a nucleus made up of protons and neutrons, with a system of electrons revolving round it. Some of these electrons are less firmly bound than others and are thus able to move from one atom to another, circulating first round the nucleus of one atom and then the nucleus of another and so on. It is the motion of these electrons which keeps the atoms in their relative positions in the lattice. Assume that the two metal electrodes are connected by means of a copper wire to a small generator. When the generator is set in motion the magnetic forces acting on the metal of the armature windings push the electrons on in a stream through the copper wires. If the circuit is open, that is to say there is no continuous circuit between the two terminals of the generator, a concentration of electrons will build up at one terminal while at the other terminal there will be a deficiency of electrons. After a very short time no further current of electrons will be able to flow and an electro-motive force is set up between the two terminals. As soon as these are connected to the two electrodes, current can flow through the system and there will be a steady flow of electrons through the wire. Any electron may be considered as flowing steadily in one direction, moving along the wire and into the nickel plate suspended in the solution. When it arrives at the metal solution interface the electron will not be able to pass across the solution in the same manner. It remains at the interface until a metal ion, which is a metal atom lacking an electron, approaches the interface. The electron will then be able to start circulating round the nucleus of this ion. As the solution being considered is a nickel solution, the nickel ions will have two electrons less than the atoms in the metal lattice so two electrons will become absorbed into the atomic system before the ion is discharged and becomes a normal atom of nickel Once this has happened the atom will take up a place on the surface of the metal sheet and become part of its lattice structure.

At the other electrode, electrons will be withdrawn from the surface to pass through the wire and back to the generator. Since the surface atoms of the nickel sheet are bound to it by a circulation of these electrons, if the electrons are pulled away the atoms will be no longer bound but will be free to move into the solution and when two electrons have been pulled away from an atom it will become an ion and enter the solution.

As a result of this mechanism nickel will be dissolved from one plate and deposited on the other.

Electrode Potential

It is well known that a certain amount of resistance is experienced when moving a body from rest, and it is necessary to use force to overcome this resistance before the object will move. It is also well known that the amount of resistance encountered depends to a large extent on the local conditions. The same thing is, of course, true of electrons. When the generator is set in motion the electrons are pushed along the wire but some resistance is encountered to their movement so it is necessary to generate a certain amount of force before they will move. The resistance

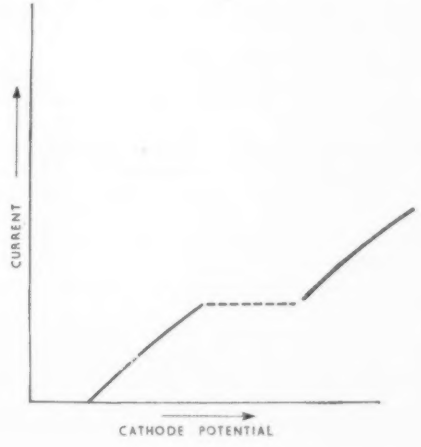
depends on the nature of the metal or other conductor through which they are passing, its size and temperature, and other physical conditions. A large force is not required to push the electrons along a copper wire because copper has a high conductivity, that is to say it is easy for electrons to move through it. On the other hand a much larger force is required to push the electrons on to the metal ion in the solution. This force known as an electro-motive force, can be measured and is expressed in volts. If the force required to move the electron through different parts of the circuit is measured, the resistance of each part can be calculated. It will be found that a comparatively high force is required to push the electron from the surface of the cathode to the solution. The resistance of the solution will be approximately equal all through and the force required will increase in proportion to distance between the two plates. Again, some additional force at the anode will be necessary to get the electrons away from the surface of the metal. The voltage between the solution and the cathode is called the cathode potential and that between the solution and the anode, the anode potential, while that between the solution nearest the cathode and the solution nearest the anode is called the IR drop or internal resistance of the cell. If the current flowing along a piece of wire is measured and the voltage across the ends, it will be found that the current is proportional to the voltage, that is to say if the voltage is doubled the current is doubled (Ohms law). This is because the resistance of the wire remains constant, assuming that its temperature does not vary. If, however, the voltage across the two electrodes in the cell already described, is considered it will be found that the relationship does not hold good and that by doubling the voltage only a small increase in current will result. If the voltages between different portions of the cell are measured it will be found that an increased voltage is required at one or both of the interfaces, and the resistance of the solution itself, again assuming that the temperature and composition do not vary, will remain constant. The resistance between the metal plates and the solution will vary quite considerably with the amount of current flowing or, to be more precise, the current density, defined as the amount of current flowing across unit area.

Current-Voltage Curves

If an electrolytic cell is connected through a variable resistance to a source of current, it is possible by altering the variable resistance, to increase or decrease the voltage across the cell. If an ammeter is placed in circuit to measure the current, and the voltage across the cell measured by means of a high resistance volt-meter or potentiometer one may be plotted against the other. This plot will not normally be a straight line as would be the case if an ordinary coil of wire or other type of resistance was being considered, but a curve which sometimes has points at which it changes direction entirely.

If a cell composed of two copper plates hanging in an acid copper sulphate solution is considered and the voltage increased slowly it will be noticed that the current will increase fairly rapidly at first but the rate of current increase becomes less above a certain voltage. A point will eventually be reached when the current increase stops, and quite a large voltage increase is necessary before any further increase in current is obtained. This is usually due to a change in the reactions taking place at the metal solution interface. It is usual to measure not the voltage across the whole cell but the voltage difference between one electrode and the solution adjacent to it. If this is done for the cathode of the system described above a rather similar curve, Fig. 1 will be obtained with a definite jump when the voltage is raised to a certain figure, depending on the composition and temperature of the solution. Further voltage increases will result in hydrogen being evolved at the cathode. What has happened is that as the current is increased more and more metal ions are being discharged until the concentration of these in the solution adjacent to the cathode is no longer sufficient to carry the current flowing through the cell. Under these circumstances part of the current must be carried by the hydrogen ions and these will then be discharged on the cathode face but since it takes more effort to discharge these ions than the copper ions, a greater force will be required and therefore the voltage will increase.

Fig. 1.—Graph of current against cathode potential showing step.



If the same measurements are taken on the anode it will be found that a similar state of affairs is produced. The reason for this may not, at first, be clear because as there are plenty of atoms on the copper surface, it would be assumed that the rate of withdrawal of electrons was unlimited. In point of fact, however, this is not so because the copper ion, that is the copper atom with two electrons withdrawn from it, can only enter the solution if there is available a negatively charged ion, for example a sulphate ion to balance it. If there are insufficient sulphate ions present at the interface then the metal ion cannot get away and will form a block which prevents further current flowing. In practice this happens particularly when the solution is cold because at lower temperatures the ions cannot diffuse so quickly. Then, the anodes will " polarize " and it will be found impossible to pass any current from the anode to the solution. This effect may be quite pronounced and it is often found that a layer of basic salts or other material is formed on the anode so that it will not function normally until it has been taken out of the solution and cleaned.

Chromium

So far only fairly simple cases of ions being dissolved from and deposited on, electrodes have been considered. Some of the cases however which are met in practice are more complicated theoretically, for example chromium deposition. In the case of chromium, this metal is present in the solution as chromic acid. Chromium can form three different ions, a divalent ion, that is an atom of chromium lacking two electrons ; a trivalent ion, an atom lacking three electrons ; and a hexavalent ion, lacking six electrons. In the normal chromium solution it is probable that both trivalent and hexavalent ions are present but the greater portion of the chromium is in the hexavalent state. It is doubtful whether there are any divalent ions, however, in the solution, although some may be formed in the cathode layers.

A considerable amount of controversy has taken place over the exact mechanism of the deposition of chromium, and a chromium deposit would not be expected from a solution of this nature because the hexavalent ion in chromic acid would form a CrO_4^{--}. ion and, being a negatively charged ion would migrate towards the anode. In point of fact, however, chromium can be plated from such a solution provided it contains a small amount of some other anion, for example sulphate or fluoride.

In order to investigate the conditions under which this action takes place, a number of current voltage curves have been plotted for a metal cathode in a chromic acid solution. It is found that if this is carefully done there are a series of steps in the curve in which the voltage shoots up and the current comes down. As the voltage is steadily increased the curves go on normally for a short period and then another step will take place. Four such curves have been described.

In the case of copper, a step of this type generally means that there is a change in the reaction of the electrode and, in point of fact, this is also the case with chromium. If a lead anode and a steel cathode are placed in a solution of chromic acid containing a small amount of sulphate and the voltage gradually increased, it will be found that after a time a small current flows which increases steadily as the voltage is raised. If the cell is carefully examined it will be seen that the electrolyte is darkening round the cathode but that no gas is evolved and on removing the cathode no chromium will have been deposited on it although a little adherent brown deposit of a chromium salt will be found. What has been happening is that the hexavalent chromium has been reduced to trivalent chromium at the cathode and the trivalent chromium has formed a complex salt with the chromic acid. This accounts for the darkening of the solution.

If the current is again allowed to rise steadily a point will be found where the voltage suddenly shoots up and it will not be possible to get a stable reading at this point, the voltage and current often going up and down in opposite direction, but with a small further increase it will be possible to obtain a stable reading and it will be seen that there is a considerable increase in the voltage and that on examining the cell, gas will be seen forming at the cathode and rising to the surface. A point has now been reached similar to that found with the acid copper cell where hydrogen is being liberated as well as reducing the hexavalent chromium. If the cathode is removed and inspected, however, there will still be no deposit of chromium on it.

By continuing to increase the current through the cell another step in the voltage will be experienced. If the current is increased slightly over this value and then held steady after a short time a deposit of chromium will be formed on the cathode.

From this study of the solution it will be seen that the first action of the current is to reduce the hexavalent to trivalent chromium, the second to liberate hydrogen and the third to reduce the trivalent chromium to the metal. It has been claimed that there is some evidence also to show that the trivalent ion is reduced to divalent before actually producing a metal deposit but this is somewhat doubtful.

As mentioned above, the exact mechanism of this deposition is still somewhat controversial but this case is described to explain how investigation of current and voltage curves may assist in

discovering the exact mechanism taking place at a cathode. If it could be discovered exactly what happens under a given set of conditions it would be much easier to control the process. It is therefore important, for a student to understand exactly what is going on in the cell and be able to think of this in terms of the motion of ions in the solution and the electrons through the metal electrodes.

Anodic Oxidation of Aluminium

With a cell containing sulphuric acid only and two aluminium electrodes suspended in it a rather different state of affairs prevails. If a current is passed from one sheet of aluminium to the other, at the cathode the current will be carried from the solution to the aluminium plate by the hydrogen ion of the acid, which will be discharged on the cathode surface to give hydrogen gas. Since there is nothing but sulphuric in the solution, nothing else will be deposited and no change will take place on the cathode surface itself.

At the anode, however, aluminium atoms will be released from the surface but these will not enter the solution as aluminium sulphate but will be oxidized in the surface layers forming aluminium oxide. If the layer of the solution adjacent to the anode is considered it may be assumed that the sulphate ion being negatively charged will approach this, and, giving up two electrons to the surface, will react with the water of the solution to form sulphuric acid liberating oxygen. This oxygen will react with the aluminium of the surface producing a layer of oxide and this layer will remain firmly adhering to the surface of the aluminium. As this process continues the thickness of the layer will grow but after a time a certain amount of the oxide from the surface will be chemically dissolved by the acid in the solution forming aluminium sulphate. Since the layer formed under these conditions is not completely continuous the current will continue to flow but it is usually found, particularly at normal temperatures, that the thickness of the oxide layer will not increase greatly after a certain time. If, however, the solution of the oxide is reduced by reducing the temperature then it is possible to build up thicker coatings, i.e., deep anodizing and hard anodizing.

If instead of using sulphuric acid oxalic acid is used it will be found that the layer so formed will, when reaching a certain thickness, cease to conduct and the current will fall off after a time. Even when a higher voltage is used, e.g. 40 or 50 volts no appreciable current will be obtained through the solution and an insulating layer will form on the surface. This is somewhat similar to the effect described on the copper cell with the anode polarized. These reactions form the mechanism of the commercial process known as "anodizing."

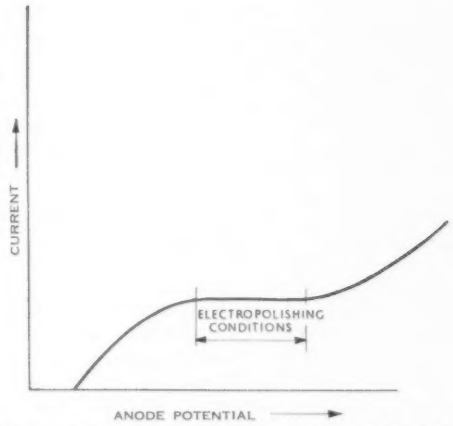


Fig. 2.—Graph of current against anode potential showing the extent of the electropolishing conditions.

Electro-Polishing

A good deal of interest has been aroused lately in processes for electro-polishing or perhaps more accurately, electro-brightening of metal surfaces. By making a piece of metal the anode in a suitable solution under suitable circumstances it is possible to produce a bright polished surface on it. This process has been used commercially with some success. Normally when the metal dissolves from an anode it does so preferentially at certain crystal faces because, as previously mentioned, it requires less energy to remove a metal ion from certain faces of a crystal than others. The result of this is that the surface becomes etched and the crystal facets show up giving a matt appearance.

If however, we can chose conditions so that the energy required to remove metal from various crystal faces and from crystal boundaries is approximately the same, then the metal will be removed equally from all parts of the surface and the etched appearance will not be produced. If a piece of metal is suspended in an electrolyte and a small current passed through it, the voltage across the interface will be low and therefore it is much more likely that the metal will dissolve from those portions of the interface from which it is most easily removed. If however this current is considerably increased a much larger potential across the interface is produced and if this is increased sufficiently the slight difference in potential between the different crystal faces will become insignificant in relation to the whole so that metal will be dissolved fairly equally from all parts. If a solution is chosen which requires a high potential for the metal to dissolve into it this will again increase the potential at the interface and enhance the effect described. Current voltage curves can

be plotted for the anode Fig. 2, and they take a somewhat characteristic form. At first the current will rise with the voltage but after a time a point will come when the curve turns over and further increases in voltage produce practically no increase in current. Then on increasing the voltage further the current will again start to rise, although probably rather more slowly. Electro-polishing generally takes place on the flat portion of this curve. If the current does not vary greatly with the voltage then it suggests that small changes of voltage will not produce changes in the rate at which the metal is dissolving which must, of course, be proportional to the current and therefore that the metal will dissolve equally from all parts of the surface.

However, dissolving metal equally from all parts of the surface will not, in point of fact, change the contour of that surface and will not therefore brighten it. Metal must be removed preferentially from the outstanding portions of the surface than from the re-entrant portions. Again a good deal of controversy has arisen as to the exact method by which this is accomplished and several theories have been put forward. It is quite possible that the actual mechanism is a combination of several of these.

If a rough surface is considered and the surface assumed to be of wave form we can imagine what will happen if the metal is dissolved away equally from all portions of this wave. If the peak of the wave is considered, then as the metal dissolves, the surface of this will recede at a certain steady speed. A portion down the slope of the wave, will also recede but since there is a surface on each side of the peak this part of the metal will be attacked from both sides and will be eaten away at something like twice the speed. At the trough of the wave, however, there will be no side action and it will be attacked at the same speed as the peak. If these lines are plotted it will be found that due to this side action, the outstanding portion of the surface will be eaten away more quickly than the re-entrant portions and this will tend to flatten it.

If the wave and the electrolyte surrounding the surface is again considered it will be seen that since the outstanding portion of the surface projects into the solution the current distributed will be higher at this portion than at the re-entrant portion. This will mean that more metal will be dissolved from these portions which will again tend to produce a flattening effect. Finally, there is a possibility that some of the solution products from the metal surface will tend to congregate in the re-entrant portion of the surface and produce an insulating film protecting these so that the prominent portsions tend again to dissolve more quickly.

It is possible that all these three reactions may take place and some experimental evidence has been found for them. However, it is an experimental fact that a considerable amount of smoothing and brightening can be obtained if certain metals are made anodic in certain solutions under controlled conditions. The structure of the metal itself, however, and its purity is very important, it being very difficult to obtain satisfactory results on biphase alloys or metal surfaces containing impurities. In practice it is usually found that solutions of phosphoric acid and chromic acid are most suitable for copper alloys, while aluminium can be electro-polished in certain alkaline solutions. All these processes require relatively high current densities in order to obtain the condition described above and it is generally necessary to keep the article in motion or the solution agitated.

Chemical Polishing

It is possible to obtain a bright surface without the aid of an externally applied electric current by dipping a metal into a certain mix of acid brightener. This can be effected in a very similar manner to the electro-polishing process described above.

The exact mechanism of this process again is also obscure.

Conditions are chosen so that the metal dissolves equally from all crystal faces and it is probable that the action is somewhat similar to that of electro-polishing, namely that in the first place there is a side attack on the outstanding portions of the metal surface, and in the second that a concentration of the solution products in the re-entrant portions prevents or slows the action of the acid on these portions. Under these circumstances it might be expected that a bright surface be produced instead of the more usual etched surface which is obtained under the more normal conditions of solution.

(*Series to be continued*)

Plastic Coatings Developments

A SERVICE for those interested in plastic coatings has been announced by Dohm Ltd. (Plastics Division), 167, Victoria Street, London, S.W.1. This service comprises the supply of raw materials, low-cost plant to apply them and a technical advisory service which includes the training of users' operatives. The company can supply nylon powder suitable for dip and spray coating. A polyethylene powder for dipping and spraying is also available. Plant and equipment available include large and small dip-coatings machines, flame spray guns etc. and in addition the company will make special machines to specification.

Testing Anodized Aluminium

By F. C. PORTER, M.A., A.I.M.*

(One of a series of lectures, presented under the title of "Recent Developments in Electrolytic Metal Finishing" at the Borough Polytechnic, London, and published by permission of the Principal).

WHEN aluminium is anodized, the surface layer consists of forms of aluminium oxide with modifications derived from the electrolyte or from the alloying elements of the basis metal. The films formed in different anodizing electrolytes have some differences in composition ; thus, in films formed in sulphuric acid, 13 to 15 per cent. sulphate may be present, in phosphoric acid about 6 per cent. phosphate, while those formed in chromic acid contain only about 0.2 per cent. chromate. On sealing anodized aluminium in aqueous solutions some water is chemically retained in the film at the sealed surface which corresponds mainly to the formula $Al_2O_3.H_2O$. The unsealed film, however, is virtually anhydrous.

The anodic film always includes a hard, thin compact "barrier" layer next to the metal. In electrolytes which do not have a solvent action on aluminium oxide (*e.g.* boric acid) this is the only film present and has a thickness in Angström units of about 13 to 14 times the anodizing voltage. In electrolytes which have a solvent effect on the aluminium oxide layer (*e.g.* sulphuric acid) an outer, much thicker, porous film forms.

In testing anodized aluminium the appearance and colour are important but the critical factors in most applications are the thickness of anodic film which is present and the quality of sealing. These two factors, together with the nature of the aluminium used, determine the corrosion resistance of the material. The abrasion resistance of the anodized aluminium is another property which can vary widely and which depends largely on the processing conditions involved. Because the anodic film formed in some electrolytes, notably sulphuric acid, can be transparent, considerable importance attaches to the reflective properties of the underlying aluminium. Mirror-like finishes can be produced on many aluminium materials, the high polish being retained permanently by protective anodizing. In recent years, particular interest has developed in the electrical properties of the anodized coating. The best known is the voltage breakdown characteristic which is closely related to film thickness for a specific alloy, but with the advent of anodized aluminium for electrical windings, many other properties such as the power factor and the permittivity become significant.

British Standard 1615 : 1958 "Anodized Aluminium" gives a number of test methods while several others mentioned in this article are under consideration for inclusion in a revised edition of the Standard.

Film Continuity

Film continuity methods are primarily used for evaluation and control of continuously anodized strip, foil and wire.

Surprising though it may seem, there is often doubt as to whether a surface has been anodized or not. A rough check for the presence of an anodic film is to touch the relevant surface at two points with the probes from a meter set to measure resistance ; this however is not an adequate test for film continuity as no current will flow if the surface has an anodic film at either of the points touched. Scratching an anodized surface with a knife will cause film cracking which is easily heard.

A chemical method for detecting breaks in an anodic coating involves immersion in

Crystalline copper sulphate	20 gm.	5 minutes
Hydrochloric acid	20 ml.	at 15-20°C
Water	1,000 ml.	(59-68°F)

Increasing the concentration of each chemical to 10 per cent. can reduce the time required to 15 seconds. Black spots appear where no anodic film is present; the reagent does not affect the anodic film.

*Aluminium Development Association.

An alternative method is the use of the Duffek apparatus[1] in which a 24-volt potential is applied through an 0.01N sodium alizarin sulphonate + 0.01N sodium chloride solution to the anodized surface which has been made the anode. Pores are revealed by decomposition of the red dye while the total current passing is the measure of the total defect area.

The use of conductive rubber rollers on foil or strip is valuable for detecting conductive inclusions, but does not readily show up pores.

On wires where it is difficult to use a roller method, it is possible to use a mercury bath but the test material must be scrapped subsequently due to the corrosion hazard, while the test itself must be carried out well away from aluminium materials. Test details (as developed for enamelled copper wires) are given in B.S. 156 (Appendix D).

Film Thickness, Weight and Density

For reference purposes, the film thickness should be measured on a micro-section. Care must be taken that the section is at right-angles to the surface or an erroneously high reading will result. The thickness of the anodic film is more readily seen if the test piece is tightly wrapped in aluminium foil before it is mounted in resin, while a pack of test pieces may be interleaved with foil. At least two sections should be taken at right-angles (equal lengths as far as possible) and the average measured thicknesses recorded over a total length of at least $1\frac{1}{2}$ in. This average should not be less than any specified minimum thickness, although normal practice permits local points as thin as 80 per cent. of the specified minimum. Wire and narrow strip are examined on the cross section only. With anodized coatings thinner than about 3 microns the percentage error in measurement is likely to be large and in such cases it is usually more accurate to estimate the film thickness from the film weight (determined by the stripping method given below) used with an empirical value of the coating density.

Transparent films up to about 3 microns thick may be measured under the microscope however by focusing (a) on the film surface and (b) on the metal film interface. Experience is needed, however, to avoid focussing on reflections.

Direct micrometer measurement may be made before and after stripping for approximate thickness determinations on thick films.

The average coating weight can be determined by weighing the dry test piece before and after stripping the anodic coating in a boiling solution of 35 ml. phosphoric acid (s.g. 1.75) + 20 gm. chromic acid (analytical reagent quality) made up to 1 litre with deionized water. The stripping sequence is continued until the weight of the test piece remains constant. Some alloys, notably those containing magnesium or copper, may continue to dissolve slowly with time and a correction evolved graphically may be applied, but for general purposes the error is unimportant.

An average thickness may be calculated from the formula given in B.S. 1615 :—

$$T = \frac{10W}{AD}$$ where T = thickness of coating in microns

W = weight of coating in milligrammes

A = surface area of anodic coating in square centimetres

D = density of coating in gm. per ml.

For general purposes, D is taken as 2.5 for an unsealed coating and 2.7 for chemically sealed coatings. However, density can vary widely and indeed the minimum density may itself be specified.

Two densities may be measured for anodic films:

(a) the "apparent" density derived from direct measurement of film thickness and film weight —this is the density measurement most frequently referred to in the literature,

(b) the true density derived using the weight of the coated specimen in air and in a highly penetrant liquid, *e.g.* toluene, which will enter the pores of the anodic coating.

The amount by which the true density is greater than the apparent density is related to the percentage of pores in the anodic coating.

The porosity referred to above is the micro-porosity inherent in the structure of the anodic film formed in solvent electrolytes and is not to be confused with harmful micro-porosity—rarely encountered, due to metal defects or extreme operating conditions.

A high density film, *e.g.* a heavily dyed or pigmented coating where the density may rise as high as 4, will appear much thicker than it really is if the standard density values given above are used. In addition to effects of pigmentation or of alloy, the density of sealed films varies with the thickness: one series of determinations on sealed films showed 3.2 gm. per ml. at 3 microns thickness, decreasing to 2.7 gm. per ml. at 18 microns. One manufacturer in the U.S.A. (General Motors) specifies a minimum coating density of 40 gm per sq. in. (2.44 gm. per ml.). The aluminium-copper alloys may give density values under 2.0 gm. per ml. and with nearly 50 per cent. pore volume. High anodizing temperatures and high acid concentrations (i.e. high coating solubility) give low densities due to a high air-filled pore volume. With sulphuric acid electrolytes containing chlorides, used for some continuous anodizing processes, values of 1.7 to 1.95 gm. per ml. have been obtained.

When the anodic film is in practice sealed with organic materials that prevent dissolution in phosphoric/chromic acid the stripping test may be applied on unsealed films.

Non-destructive test meters based on eddy current principles (see AS.T.M. specification B.244) are suitable for routine inspection work and indeed for many research purposes. The test head of such instruments is a small coil energized by a high frequency oscillator. This oscillator induces an eddy current in the basis metal and the reaction on the coil is used to indicate the separation of the probe from the base metal, i.e. the thickness of the anodic film. As with micro-sections, no measurement should be less than 80 per cent. of the specified minimum thickness, and the average of the measurements should exceed the specified minimum. Commercial instruments currently available include :— . .

Isometer—Solus Schall Ltd., 15/18 Clipstone Street, W.1.

Accuratest—Nash & Thompson Ltd., Oakcroft Road, Chessington, Surrey.

Dermitron—Unit Process Assemblies, 59 East 4th Street, Manhattan, New York, U.S.A.

Filmeter—American Instrument Co. Inc., Silver Springs, Maryland, U.S.A. (operated from batteries).

Unfortunately the battery instrument requires a flat area of 2 in. diameter for measurements compared with $\frac{1}{2}$ in. diameter for the majority of the mains instruments. While useful results can be obtained with all these instruments, careful calibration is necessary as alloys, surface roughness, thickness and curvature of metal, distance from edges and evenness of pressure on the test probe, are all factors which may influence the readings

Sealing

For many years a dye absorption test, using either an aqueous or a chloroform solution of an anthraquinone violet dye (see B.S. 1615) was regarded as an adequate test for sealing. This test is still adequate for anodized aluminium where its corrosion resistance is not severely tested, e.g. domestic applications. The purity of the dye solution is important[2].

For aggressive environments, *e.g.* outdoor architectural uses and car trim, a more searching test for sealing is necessary and a sulphur-dioxide/humidity type of test is most appropriate and is proposed for inclusion in B.S. 1615. The apparatus and method are identical to those described in B.S. 1224 (Method E) for use as a corrosion test on plated steel.

The corrosion medium is moist air of 95 to 100 per cent. relative humidity containing 0.5 to 2 per cent. (vol.) sulphur-dioxide. The test is conducted at a temperature of 25 $\pm$ 2°C. and precautions are taken against rapid temperature fluctuations during a test. An alternative test apparatus is one originally built for humidity testing of paint panels (Ministry of Defence Specification DEF 1053, Method 25). This uses a reservoir of sulphur-dioxide in solution (100 ml. of 5 per cent. sulphur-dioxide solution added to water bath immediately before the test) and the cabinet temperature is cycled between 42° and 48°C. hourly. It is essential that the tank lining is resistant to sulphur-dioxide and a stainless-steel is suitable.

Degreased samples are subjected to either test for 24 hours and after removal from the corrosive atmosphere specimens are lightly rubbed with a soft damp cloth to remove superficial grease. Both tests reveal bad sealing as a heavy white bloom on the surface of the anodized test piece. Slight surface bloom may be neglected. Until adequate experience has been gained by a user with this test it is recommended that a specimen anodized at 15 amps per sq. ft. in 15 per cent. sulphuric acid for 20 minutes and sealed in deionized water *p*H 5.5 to 6.5 for 20 minutes at 100°C., shall be included for comparison.

The test is not an alternative to the acetic acid/sodium chloride spray test. The time taken to form the bloom is largely independent of anodic film thickness.

For quality control purposes, the comparable simple and quick Kape[3] sulphur dioxide solution test may be used. A solution of 10 g. sodium sulphite (anhydrous) in 1 litre of deionized water to which glacial acetic acid is added to give *p*H 3.75, followed by addition of 5N sulphuric acid to give *p*H 2.5, is maintained at 90 to 92°C. and the sample (which can be of any convenient shape) is immersed for 20 to 30 minutes. Again bad sealing is revealed by a heavy white bloom on the surface coating. Unless very large parts are tested, the baths should be made up fresh for each test.

The Kesternich[4] and the CRL beaker test may also be adapted as tests for sealing.

Resistance to Leaching

Leaching of dye from coloured anodic coatings in some solutions is not necessarily a sign of bad sealing ; where necessary, tests in the specific solutions involved should take place. The test given in B.S. 1615 : 1958 of boiling in 0.1N borax solution, while of some limited value, does not give results universally applicable to other boiling solutions.

Corrosion Resistance

When the alloy, coating thickness and adequacy of sealing have been determined the relative atmospheric corrosion resistance may be reasonably assessed. For many decades, attempts have been made to develop accelerated corrosion tests that could take the place of long term atmospheric exposures, but no complete answer has yet been found. However, various types of sodium chloride/

acetic acid continuous spray tests have some value in reproducing the type of pitting effects obtained on lengthy atmospheric exposure. Different forms of the tests operate either at room or slightly elevated temperatures and both temperature and *p*H require careful control if reproducible results are to be obtained.

The most widely used sodium chloride/acetic acid test apparatus is given in B.S.1224 (Method E) where it is a corrosion test for nickel/chromium plated coatings on steel, brass, copper or zinc. Test apparatus conforming to Ministry of Defence Specification DEF.1053 Method 24 may also be used.

The solution is prepared by dissolving 5 ± 0.5 parts by weight of sodium chloride in 95 parts by weight of deionized water to which is added glacial acetic acid, until the *p*H of the solution is in the range 3.2 to 3.5. A fine continuous spray is provided such that 1.0 to 2.0 ml. of solution are collected per 12 in. sq. (horizontal) each hour. Temperature in the test cabinet is 35 ± 3°C. The sprayed solution is not recirculated owing to the danger of corrosion products affecting the test result.

In constructing the apparatus, it is important that metal parts should not be in contact with the spray.

Degreased test specimens are left in the spray continuously except for inspection purposes. No standard data has been published on length of test but 24 hours may be regarded as a minimum for thin anodic films but the thicker anodic films used for architectural applications do not have as long a life as might be expected from their known high atmospheric corrosion resistance. The exact figures are markedly affected by the criterion of failure adopted and it is probable that the main use of this test will be for quality control of anodic films rather than for attempted absolute determinations of life.

Abrasion Resistance

Three distinct properties are included under abrasion resistance, namely resistance to impingement attack, resistance to rubbing and resistance to scratching.

Both in the B.S. 1615 method and in the American Bureau of Standards apparatus, resistance to impingement is determined by propelling abrasive against the anodized surface. In the method now being adopted in this country[5], two vertical concentric tubes with controlled pressure air in the outer and silicon carbon abrasive in the inner combine to send a jet of abrasive against the specimen held at 45 deg. to the direction of the jet. The abrasion resistance is measured by the weight of abrasive needed to penetrate the anodic coating. It is preferably expressed as gm. per micron of coating thickness, but with thick coatings the weight of anodic film removed per unit weight of abrasive used may be a more convenient measure of the surface abrasion resistance.

Difficulties in preparation of standard test pieces and obtaining reproducible batches of abrasive give rise to difficulty in specifying absolute standards of abrasion resistance although duplicate instruments give reasonably reproduceable results (± 10 per cent.).

A simple abrasion test for works control of hard anodizing (see DTD 930) is to rub grade OO (B.S. 871) emery paper two or three times over the surface using medium finger pressure. The paper should skid over the surface and not abrade the coating — at the most a faint trace of whitening on the emery paper is permissible. In all rubbing abrasion tests, it is important that abrasive material detached on the surface should not be allowed to remain there to increase the abrasive effect, while high speeds are likely to give anomolous effects due to over-heating. Nevertheless a commercial instrument of this type, the Taber Abraser*, has proved to be of considerable practical use.

Micro-hardness tests are valuable both used on the surface of the anodized coating and on a cross-section, although in the former case care must be taken to ensure that the loading is sufficiently light to prevent the basis metal influencing the results. A micro-hardness tester may also be used to produce a scratch, in which case the scratch width is directly related to the surface hardness. Scratch tests by using loaded hemispherical points (c.f. test for paint DTD 62B) or more simply by using natural pieces of the minerals in Moh's scale, have been proposed for qualitative tests.

The relationship between service conditions and any of these test methods is difficult to establish ; moreoever, there still remain variables inherent in the tests currently used. Inadequate quantitative data is available for assessing standard performance figures for any of these tests and individual trials are desirable to determine an appropriate standard of acceptance in any particular application.

Reflectivity of Light

Highly reflective surfaces are obtainable on most purities and alloys by chemical or electrochemical brightening or polishing. Except with super-purity base materials, the reflectivity is diminished by anodizing, but by appropriate selection of material and brightening process together with use of sulphuric acid anodizing, a permanent reflectivity greater than that of chromium plate can be obtained.

* Taber Instrument Corporation, N. Tonananda, N.Y., U.S.A. British agents Funditor Ltd., 3, Woodbridge Street, London, E.C.1.

The total reflectivity of such surfaces is high, usually between 80 and 90 per cent. and there is little practical interest in measuring the value precisely. Where required the Paint Research Station head[6], used in conjunction with the modified gloss head mentioned below, is appropriate.

The specular reflectivity is of greater importance and can vary within wide limits. For commercial requirements it may be defined as the ratio of the intensity of light reflected, within a narrow cone with its apex on the reflecting surface and its axis parallel to the angle of reflection, to that of light incident at the same angle. This ratio, which may be conveniently expressed as a percentage, varies with the angle of incidence and with the solid angle of acceptance of the measuring instrument.

Where the decorative appearance of bright anodized aluminium is important, the specular reflectivity and the image clarity are most important as the normal variations in total reflectance do not significantly affect the overall appearance. Where the light reflection properties of the surface are important, measurements of one or more of the properties (a) total reflectivity (b) specular reflectivity and (c) image clarity, may be required.

Several instruments are available for the determination of specular reflectivity, differing only in their criteria of specularity. The Guild[7] meter has a relatively large solid angle of light acceptance and therefore can give results not in accord with subjective visual assessment. A design based on a modification of the gloss head described in Defence Specification DEF. 1053, Method 11* is more appropriate[8]. Specular reflectivity is compared at an angle of incidence of 45 deg. and a solid angle of acceptance of about 0.0015 steradian. The reflected light, suitably directed, is measured by means of a photo-electric cell in conjunction with a galvanometer equipped with a variable shunt. The reflectivity of a sample which *must be flat* and at least 6 in. x 3 in. is measured by placing the gloss head with its face firmly in contact with the sample and noting the reading of the galvanometer.

A suitable reference surface is the hypotenuse of a 45 deg. right angle prism with total internal reflection of the incident light when the absolute specular reflectivity is almost exactly 90 per cent.

It is most important to note that specular reflectivity of a surface when measured by the modified gloss head will be much lower than when measured by the older-established Guild meter used for most results reported in British literature. Most specular reflectivity measurements given in German work however are closer to gloss head than to Guild measurements.

* Instruments conforming to DEF. 1053 Method 11 are made by Evans Electroselenium Ltd., Halstead, Essex and by Sheen Instruments Ltd., Sheendale Road, Richmond.

The image clarity of anodized aluminium is of major practical importance and may vary markedly on surfaces with the same specular reflectivity. It is conveniently measured by use of the Gardam Grid[9], a test which is suitable for routine inspection purposes. Correlation between gloss head and Gardam Grid readings is reasonably good but poor correlation is found with Guild readings.

The Gardam Grid consists of an oblong box containing a strip light and open at one side which can be filled in with a glazed screen, suitably marked out with black stripes, e.g. in Indian ink. The strip light covered by frosted or purled glass illuminates the glazed grid and the surface to be measured is usually held by the operator in his hand while he walks away in line with the Grid. Alternatively, the surface may be placed directly under the Grid.

The operator proceeds until he can no longer clearly resolve the Grid lines as reflected in the specimen (it should be clear that the operator must have normal eyesight, i.e. his near point should be 25 cm $\pm$ 2 cm.). The distance from the operator to the Grid is then measured and is proportional to the image clarity of the specimen.

The size of the grid pattern has not been finally standardized, both a coarse grid having $\frac{3}{8}$ in. squares and strips and a fine grit with $\frac{1}{8}$ in. squares and strips being under consideration. The latter is preferable with specimens of good image clarity while the former is better for those having poor image clarity.

Insufficient testing with the Gardam Grid has yet been carried out to enable absolute figures to be standardized : the main value of the Grid at present is for routine inspection of surfaces which have been standardized by means of reference samples. Reflectivity can, however, be standardized but the values given in B.S. 1615 : 1958 will need to be greatly lowered if the modified gloss head is accepted as the reference method for measurement of specular reflectivity.

Fastness to Light

Unimpregnated anodized surfaces, (silver with pure aluminium and grey with aluminium-silicon alloys), are fast to light. Dyed and pigmented coatings have varying degrees of permanency. For interior work, dyes with a colour fastness number lower than 5 (determined according to B.S. 1006, Part 2) should not be used. Externally a light-fastness number of at least 8 is required, but experience has shown that only a few selected dyes and pigments[6] all of which have a light-fast number of 8, give full colour retention for 5 to 10 years or more outdoors.

Reliable evaluation of light-fastness can only be by long-term outdoor exposure tests. Where a dye of proved fastness to light has been used, an accelerated test may however be applied for quality

control of the process. Suitable apparatus includes many of the accelerated weathering cabinets such as the Weather-O-Meter*. The test essentially involves exposing the test sample together with reference textile standard dye cloths until a standard colour change has occurred. With different instruments, however, the complexity of the test cycle varies with the nature of the ultra-violet source and other factors may also affect the result.

Thermal Properties

Anodic films do not blister or peel but at temperatures above about 100°C. the film may become crazed because the co-efficient of thermal expansion of the coating is only about 20 per cent. that of aluminium ; also dehydration may occur. This crazing is mainly objectionable on decorative finishes or where maximum corrosion resistance is needed. Chromic acid coatings craze less than comparable sulphuric acid films. The crazing is best tested by simple heating procedures.

The infra-red reflection factor is determined (B.S. 1615) using a 2 in. square sample of flat sheet, preferably 20 s.w.g. One side is blackened and then each side in turn is exposed to a standard radiation source enabling the reflection factor to be calculated and heating curves to be drawn. Infra-red reflectivity decreases (and emissivity increases) rapidly with increasing anodic film thickness, while to obtain increased infra-red reflectivity, the hot water sealing of the anodic film is omitted and replaced by heating at 160 to 170°C. for half to three quarters of an hour and waxing while still warm. This avoids an absorption band at wave lengths of about 3 microns ascribed to the hydrated film.

Electrical Properties

The electrical breakdown voltage is often determined as it has a relationship with the thickness of the anodic film and a commercial instrument based on this property has been marketed for film thickness determinations. Caution is needed for the use of such instruments, however, as the voltage breakdown characteristics for different alloys are markedly different[10]. In the standard test (B.S. 1615) a hard spherical electrode of 1/16 in. radius wth a 50 to 75 gram load is in contact with an undeformed anodized test piece. Constant electrical contact is maintained across the secondary winding of a transformer between (a) the electrode and (b) the base metal on the underside of the test piece. Voltage is increased uniformly at a rate not exceeding 25 volts per second until electrical breakdown occurs.

The breakdown voltage of unsealed films varies with the humidity so that humidity control is required.

* Weather-O-Meter, Atlas Instrument Co.

Other test instruments use probes of different designs, a disc type being popular. With all these instruments wide scatter between individual results is often found and in quality control tests readings should be at least in triplicate. The use of test instruments with two test probes is not recommended for general use because the risk of an anomolous probe/coating contact is doubled and leakage current effects may occur on the anodized surface.

For wires, the usual electrical test method (see B.S. 156 Appendix C) involves making a standard twist joint with two wires and gradually increasing their potential difference until breakdown occurs.

With the increasing use of anodized aluminium for electrical windings, however, other properties are now beginning to be studied in some detail, including capacitance, power factor and insulation resistance. At present the applicability of conventional electrical methods for evaluating these properties is being examined.

Conclusions

Anodized aluminium can possess a wide range of properties and for their full evaluation a considerable number of specific tests have been devised in addition to those appropriate to other surface coatings. In practice, however, for many applications few of these properties need to be determined. The most important factors are the thickness of the anodic coating together with the adequacy of sealing : most applications also require the anodic film to be reasonably abrasion resistant. Specific tests are available for applications involving either electrical characteristics, heat or light reflectivity or colour fastness.

Acknowledgments

In preparing this article, my sincere thanks are particularly due to colleagues on the British Standards Institution Committee (CHE/18/3) concerned with revising B.S. 1615 " Anodized Aluminium " for many helpful discussions. The permission of the Aluminium Development Association to publish this information is also gratefully acknowledged. It will be noted that many of the methods described in this article are under consideration for possible inclusion in a revised edition of B.S. 1615.

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Some ADVANTAGES of AUTOMATIC PLANT USING SOLVENTS FOR DEGREASING

by
J. PICKUP *

IT is a well-established tenet in the finishing trades, particularly with reference to the field of metal cleaning, that processes carried out automatically produce superior results to those carried out by hand. Nowhere is this more apparent than in solvent degreasing using trichlorethylene or perchlorethylene.

The reasoning behind this is quite simple. The removal of dirt from objects is an unpleasant job at the best of times, and any labour engaged on the work is almost certainly to be of a type that cannot be more skilfully employed, consequently, the job tackled in this manner can hardly be said to be receiving the best attention. Furthermore, in order to speed up the operation the work is very often carried out on piece-work conditions, so that quantity rather than quality is the aim.

This may be all very well in certain applications where the standard of work cleanliness may not be high, but to the manufacturer producing a quality product it is essential that, before attempting such processes as plating or stove enamelling, or even straightforward assembling in some cases, it is absolutely essential that the components are thoroughly degreased.

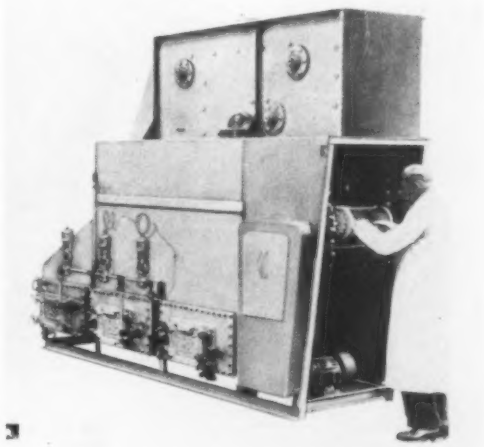
A quick dip in a dirty open tank of solvent is not the answer. In addition to giving faulty degreasing, this method has the additional and possibly just as serious shortcoming of causing excessive " drag out " with its attendant high cost, and, in so doing, of aggravating the toxic problems associated with solvents.

It is apparent, therefore, that if the whole operation of loading into, timing the process, and unloading out of the degreasing tank, can be made automatic, these many faults and disadvantages can be overcome.

One such application is that of Mallory Batteries Ltd., at Dagenham, who are engaged in the mass production of miniature batteries for deaf-aids and similar uses, and to whom it is vitally important that the cases of batteries are completely clean before going to assembly. These components, being cup shaped and in some instances having a very great depth/diameter ratio, created their own problems of degreasing and drag-out. If they were not loaded properly the presence of air in the components would prevent the entry of solvent to allow it to do its work, and conversely, if the solvent were not removed from the components the rate of " drag out " would be enormous.

The use of an automatic type of machine solves these problems and a fully-automatic double-immersion machine was in fact installed. This machine, which is of the return type, gives the components two entirely separate but complete immersions in boiling trichlorethylene, a " dirty " and a " clean " immersion in fact, before passing through a vapour zone as an aid to drying. Through

Fig. 1.—Return type double-immersion vapour degreasing machine.



* Manager, Metal Pre-Treatment Division, Dawson Bros. Ltd., Gomersal, Nr. Leeds.

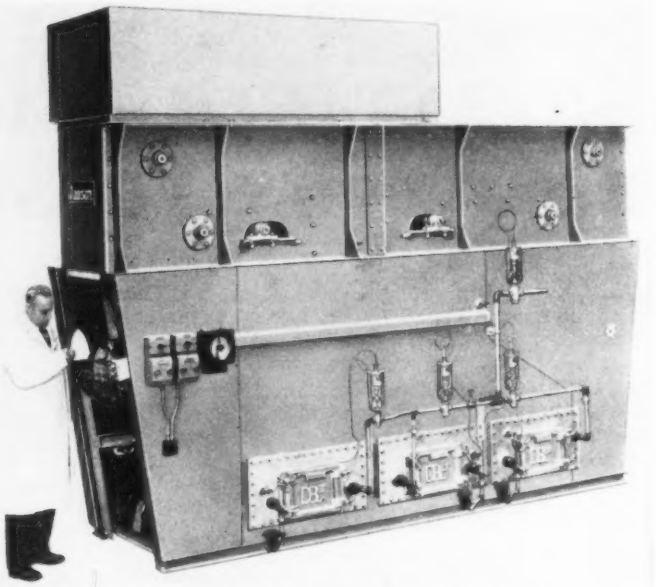


Fig. 2.—Double-immersion vapour degreasing machine for straight through operation, the parts being loaded at one end and removed at the other. This particular machine is shown with the solvent storage tank fitted on top.

all these sections the components, which are loaded in circular baskets, are continually rotated ensuring entry of solvent into components for cleaning, and, furthermore ensuring removal of solvent from components after cleaning.

The first dwell in each station is automatically controlled by an adjustable timer.

Proof of the efficiency of this method of automatic handling in solvent is manifested by the fact that the loss of solvent is almost negligible.

Cylindrical baskets of this type can be arranged so as to be fixed to the chains for direct loading and un-loading, or can equally well be made detachable so that the baskets of clean parts can be removed from the conveyor and replaced with a basket of soiled parts. They can also be rotated during treatment, or not, in which case they simply pivot, retaining the same gravitational disposition throughout their journey through the machine. Rotation is usually effected by sprokets on the ends of the baskets which contact chains of specially robust design which are fitted along the course of the conveyor in the treatment zone, providing smooth rotation throughout the cleaning process.

To further reduce the already small amount of manual effort required to operate the machine the installation at Mallory Batteries Ltd., is fitted with a simple but efficient un-loading arrangement. This consists of a short chute pivoted about a point on a radius arm and inter-locked electrically with the conveyor motor starter. When the work basket arrives at the discharge point the operator simply swings the discharge chute into position and revolves the basket to an inverted position, allowing the components to fall freely into the chute. The chute itself is fitted with a sliding door at one end so that when the chute is

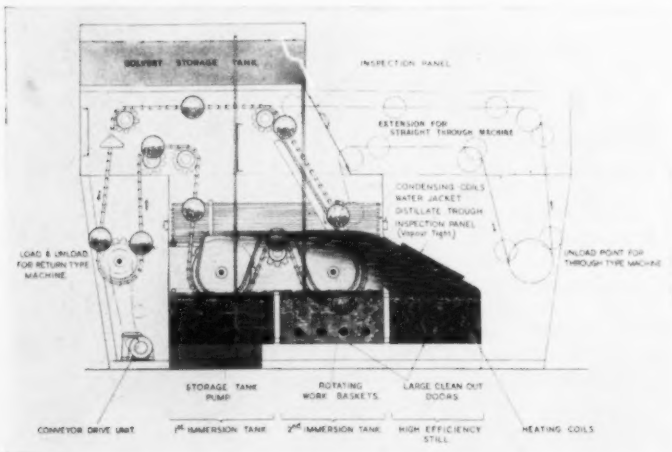


Fig. 3.—Operation diagram for double-immersion vapour machine. This shows the return-type machine, and the dotted section indicates arrangement for straight-through machine.

swung to the out position the sliding door is raised and the work can then be discharged onto a conveyor which will carry it to the next stage in the production line.

Similar automatic arrangements can be made for rectangular baskets, and the author knows of an instance where quite heavy baskets of work, up to 100-lb. in weight, are man-handled into and out of the machine without any lifting whatever on the part of the operator, this being done with a quite simple but, nevertheless, fully automatic arrangements of gravity tables and locks.

An interesting variation on the above was a machine recently installed by Hoover Ltd., at High Wycombe, where the problem was to remove polishing soiling from the highly polished die-cast aluminium sole plates of the Hoover steam iron. In this case the same machine was considered but arranged for " through-type " operation. The problem of penetration by solvent or drag-out by the components was not present on this application, but it was vital, from the tests carried out at the experimental stage, that a minimum process time be adhered to, and the " in-line " operation was also desirable. Both these features could be adequately met by an automatic machine, and the plant is now installed and working satisfactorily.

With any fully automatic machine, as of the types described above, it is essential that they should be capable of running for the very maximum period without attention for maintenance or cleanouts.

A natural essential, of course, is robust construction, but designed to do the job in hand ; accessibility must have top priority in the designer's mind so that, when the time does come for periodic inspection and cleanout, it does not become a " can-opener " job. This feature should be given very careful attention and easy access to the interior of the machine should be provided wherever possible by large, quickly removable mud doors on the side of the tank ; these should be mounted on even larger sized coil plates so that when these are removed virtually the whole side of the machine is laid open for access. The important feature of machines for steam or H.P.H.W. heating is that the heating coils can be mounted on such easily removable plates bolted to the side of the tank. In addition, separate inspection panels over the high capacity still and at other strategic points should be incorporated to make it possible to work with complete ease inside the machine, if this ever becomes necessary. It need hardly be added that for normal cleanouts, with the large areas of the tank side being removed as described it will not be necessary for personnel to enter the tanks.

The frequency of the cleaning down periods will, of course, vary widely according to the amount and nature of the work with which the machine has to cope. One instance of which the writer has knowledge ran for a full four months before the tanks were opened up for cleanout, while another large installation handling enormous volumes of heavily-soiled small components should, in all fairness, be cleaned out twice a week. However, with an integrally incorporated distillation plant capable of distilling all the solvent in the tanks the frequency of cleaning down times should not give the maintenance staff cause for concern.

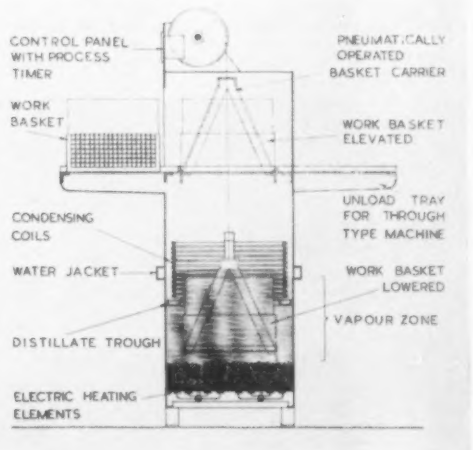
Other important features in automatic practice are the ability to check on the rate of distillation or the rate of flow of cooling water, and sight glasses have been found to be very useful accessories, in fact they should now be regarded as essential fittings, thus, enabling the operator to carry out spot checks on these two important items.

Another standard fitting should be a cooling water outlet thermometer. This should be marked with a red line at the optimum temperature, thus giving early warning to the operator of reducing water supply and avoiding the necessity for the high level safety thermostats to come into operation with constant difficulties in locating faults after a shut down has occurred.

The rate of flow of cooling water should ideally vary with the volume of work being cleaned ; the normal practice is however, to set this to a maximum opening and forget it. An alternative to this, and more economical, is to set this to a minimum and, by means of a sensing thermostat, operate a booster valve to pass the additional cooling water as and when required.

This would seem to be an advantage over other systems, in that the flow of water is automatically

Fig. 4.—Diagram of vapour dip machine for batch operation. This machine is also available as an immersion-vapour machine.

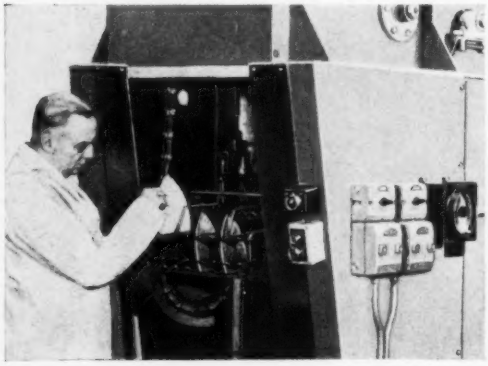


adjusted to suit the work passing through the machine. For example, less vapour condenses on light parts than on heavy parts, therefore, where a variety of parts are being handled, the amount of vapour rising to the condensing coils could vary considerably ; it would also ensure that only the minimum amount of water necessary for cooling would be used, whereas, on the system where the flow of water through the coils is manually fixed to suit the lightest work handled, the water consumption would be much higher than is actually necessary.

A most useful addition to the automatic plant would be an integrally constructed high-capacity still, mentioned earlier. This should be designed to serve two purposes. Primarily, its function would be to maintain a high standard of cleanliness in the actual processing tanks of the machine, but it should, in addition, perform the extremely useful function of enabling the whole of the solvent contents of the machine to be distilled off into a storage tank at a very rapid rate to speed up cleanout times.

Plant incorporating this feature has shown considerable improvement on other machines of this type where the still is a separate unit. This in-built distillation system ensures the maximum possible recovery of vapourized solvent and, by a system of overflows, it weirs surface dirt and sludge from the immersion tanks into the still tank. The rising vapour from the boiling solvent in the two immersion tanks and in the still tank enshrouds the carriers and their contents and rises into contact with the condensing coil which converts it into liquid solvent. This falls into a trough and is returned through a water separator to the second immersion tank, thus constantly replenishing and refreshing the solvent already there. From there the solvent weirs over to the first immersion tank and the surface oil and scum on that tank flows into the still. Therefore, the soilage collects in the still for easy removal at cleaning-down times through the cleanout doors provided, and the actual operating tanks are kept free of excessive soiling.

Fig. 5.—The illustration shows a typical hanging fitting. In this case the parts being cleaned are electric iron plates. The carrier is coated with a special plastic (solvent resistant) to prevent damage to the components.



The condensing coil is copper tubing through which cold water is continually circulating and this, together with a water jacket girting the outside of the tank level with the coil and connected to the same cold water supply, provides a complete cold strata which condenses the vapour and allows none to escape to atmosphere. If, for any reason such as a failure in the water supply to the condensing system, the vapour should tend to rise above the desired level, a thermostat is fitted which will automatically switch off the heating supply in the immersion and still tanks.

The foregoing safety provisions, are of course, designed to completely ensure that vapour does not escape to the atmosphere, and to protect both personnel from the possible toxic effects of fumes and also ensure that there is a minimum loss of solvent. It is, however, necessary to consider all aspects, and even the best laid plans " oft times gang agley." It is necessary to consider the final safety precaution, which would seem to be lip ventilation. This form of ventilation should be designed to deal only with that infinitely small amount of vapour which has managed to slip through our fingers in this very well designed plant, and would not have sufficient power to be a solvent extractor or a vapour extractor in its own right. It is usually not worthwhile attempting to reclaim the small amount of solvent which would be present in this extraction, and it is normal practice to expel this direct to atmosphere.

With automatic plants it is essential also that a good continuous water supply can be guaranteed, particularly so at the present time when more and more Water Boards are insisting on the incorporation of a buffer tank between the main supply and the solvent degreaser. It will be appreciated that a considerable amount of frictional resistance will be met in the refluxing coil which could quite easily absorb the whole of the pressure available from the buffer tank, which could very well be set only 6 or 7 feet above the height of the coil, so that whilst the normal Town mains pressure would be adequate to feed these coils and guarantee the adequate supply of cooling water the situation is now changed and it becomes necessary to consider the incorporation of a booster pump. This is a most important fact, and, if carefully considered at the time of the proposals and initial design will save a considerable amount of " head scratching " after the machine has been installed.

On the machine installed at Hoover Ltd., in order to conserve floor space, the solvent storage tank is located on top of the machine. This feeds the second immersion tank by gravity and from there the solvent weirs over into the first immersion tank, which in turn overflows into the still tank, thus, all three tanks are filled to the required level.

The method of distilling off is arranged so that the distillate is directed into a side tank where is fitted a small vertical spindle pump and a float switch. The pump capacity in gallons per hour is approximately equivalent to the distillate tank output in gallons per hour, and an electric float switch brings the pump into action as soon as there is sufficent solvent in the tank for the pump to draw on. The pump has sufficient head to lift the solvent up to the level of the storage tank. Thus, by this means, pure solvent is passed to and held in the storage tank until the machine is cleaned out. The levels of the process tanks are so arranged that it is possible to initially distil off the whole contents of the machine solvent.

To continue the quest for the reduction of manual labour, a simple arrangement of filling the storage tank should be considered, and one such arrangement of which the author is aware, is a small self-priming gear pump with flexible hose in suitably solvent resistent material so that, as the drums are brought to the storage point they can be immediately pumped out into the storage tank within a matter of minutes, and the drum made available for return to the solvent manufacturers without any delay. This has the two-fold advantage in that it saves a considerable amount of accountancy and paper work on checking on the whereabouts of elusive stored drums, etc., and, therefore, the system serves a dual purpose.

While on the subject of storage and automation of these plants, a considerable leakage of this expensive material is by way of devious channels as a dry cleaning agent by unauthorised persons private use, and consideration should be given to some means of pad-locking the main drain valves on both machine tanks and storage tanks. Recently the writer was called in to investigate an excessive consumption of trichlorethylene from one machine, and even while carrying out an examination of the plant, an operator from a completely different department came along with a two-gallon bucket, which he proceeded to fill and take away for his own unauthorized nefarious use. Since one of the main aims of automation is to conserve solvent, this side issue must not by any means be ignored.

Automation of solvent degreasing plants need not necessarily mean the construction only of large capacity machines. The simple open-topped dip tank has a time-honoured place in the metal-finishing engineer's catalogue, and one would be unwise to decry its usefulness, but even this small unit can be mechanized to such an extent that savings in solvent can be effected, and a better control over the quality of work be guaranteed. Small automatic totally enclosed vapour dip machines are available, taking up very little more room than the open-topped tank, and yet being suitable for a hand-operated flow-line production, These machines are usually of the cabinet type and can be arranged to deal with single basket loadings, the operator pushing the basket of work into the chamber and pressing a button, when the basket of work is lowered into the vapour zone, held there for a timed period, and withdrawn from the vapour zone at the correct speed ready for removal either into the same tray or passed through into a succeeding tray. Such a unit can be complete with all the various accessories described above to make it an efficient self-contained degreasing unit which is a valuable adjunct and aid to an operator without requiring his full time, and usually inefficient attention.

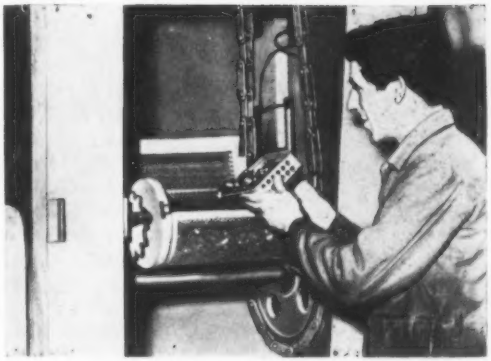


Fig. 6.—Parts being loaded into a cylindrical carrier basket of the rotating type. The sprocket seen on the left side of the carrier contacts a chain inside the treatment section to provide the rotation.

From the foregoing it will be seen that carefully thought out automatic solvent plants have much to commend them, and before considering installation of any sort of solvent plant the question of automation should be fully investigated.

ANODIZING ALUMINIUM

A CONFERENCE on the "Anodizing of Aluminium," organized jointly by the Aluminium Development Association, 33, Grosvenor Street, London, W.1., and the Department of Metallurgy of the University of Nottingham, will be held from September 12 to 14, next. It is planned that this will be a residential Conference.

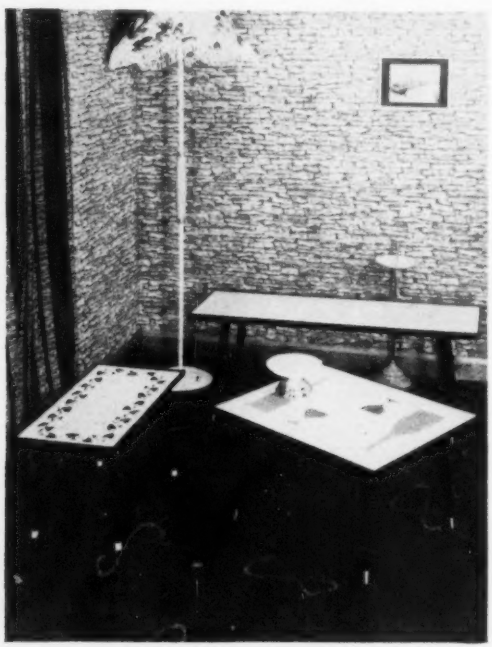
DECORATIVE VITREOUS ENAMEL FURNITURE

AN exhibition of decorative vitreous enamel furniture was held recently in London, demonstrating the products of Brockhill Products of New Street, Oakengates, Shropshire. These products aim to increase the usefulness of vitreous enamel in the home by extending the already wide range of ware available.

The initial range of items shown emphasized the very attractive effects obtained by using vitreous enamel on the more decorative features of a home, while mantaining its hard-wearing and functional properties traditionally associated with this type of finish in the kitchen and bathroom.

The exhibits included occasional tables, cocktail bars and even such things as fruit bowls, lamp standards, confectionary stands and dishes of contemporary design. The surfaces can be produced giving a beautiful finish and lustre, with attractive and novel designs embossed onto the surface. They are non-porous and acid resistant and have the hardness of glass plus the mechanical strength of the metal backing. This finish being of glass composition enables cleaning to be carried out quite simply by using warm soapy water.

Some examples of the furniture at the exhibition



Mr W. S. Grainger, president of the Institute of Vitreous Enamellers, opening the exhibition.

Brockhill Products is an entirely new venture and the chairman, Mr. John Nicholls, is the son of the late Mr. James Henry Nicholls, one of the first people to produce vitreous enamel on a commercial scale about 1870. The Nicholls family have therefore well over a century of experience in the enamelling trade. Mr. John Nicholls is currently chairman of the Institute of Vitreous Enamellers, which is the technical body for the trade and he is also chairman of the Vitreous Enamellers Association, a commercial association of enamellers.

The design of this furniture is such that when the new licensing act becomes law there will be a considerable market for bars requiring the hard-wearing properties of vitreous enamel in all the attractive configurations shown at the exhibition. One of the great features is that the colours are stable and cannot fade. Purchasers are also able to select their own designs from an extensive range of colours and also in a variety of textures.

The exhibition was opened by Mr. W. S. Grainger the President of the Institute of Vitreous Enamellers, who recalled the early days of the enamelling industry, and spoke of the great strides made in recent years, both in technique and in co-operation among enamellers. Commander Clarke, F.C.C.S., general manager of the Vitreous Enamel Development Council, also contributed to the opening proceedings.

Enquiries concerning this introductory range of enamelled furniture, for which it is hoped new designs and colour combinations will be conceived, should be made to Brockhill Products, New Street, Oakengates, Shropshire.

A Survey of Non - Electrolytic Chromate Treatments and Coatings.

(*Continued from page* 175)

The time of exposure is to 20 per cent. salt spray before appearance of white corrosion products. All should satisfactorily pass the humidity cycle previously discussed. The colour of the film produced is partly dependent on composition, treatment, metal processed, *p*H etc., as previously described.

It should, however, also be pointed out that the value of any of the discussed coatings varies also with the thickness and type of electrodeposit. A minimum 0.0002 in. deposit appears to be essential ; improved results are obtained as the thickness is increased. In the case of electrodeposited cadmium and zinc, unsatisfactory results are frequently obtained because of metallic additives and brighteners and also because of passive organic films formed on the electrodeposit. Zinc-base die-castings[11] can generally be treated in a similar manner to electrodeposits, except that they should normally be degreased, alkali cleaned and acid-dipped prior to treatment.

Galvanized iron, after cleaning, is normally activated in a solution containing phosphoric acid and butyl Cellosolve or, alternatively, by several seconds anodic cleaning in a weakly alkaline cleaner. Times of immersion are frequently some-what longer than for electrodeposited work.

Other uses of chromates in this field are the hot dichromate or chromic acid dip recommended in D.T.D.904 as an after-dip for electrodeposited cadmium.

Silver

Most of the processes available for conferring protection on silver against sulphide tarnishing are proprietary in composition and are also electrolytic. Although there is an indication that some degree of protection can be obtained from simple immersion in chromate solutions, this does not compare favourably with the results obtained by cathodic treatment.

One such typical proprietary process is based on a dichromate mixture and is operated cathodically for 1 to 2 minutes at, from 10 to 60 amp. per sq. ft. at room temperature. The resultant film is quite clear, and the silver is then able successfully to withstand 40 minutes' immersion in a solution of 2 per cent. sodium sulphide and 2 per cent. ammonium hydrosulphide.

The film does not impair the electrical properties of the metal and is therefore suitable for technical application. It is also eminently suitable for decorative applications providing the components can be satisfactorily dried without damaging the film.

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A.S.T.M. Prepare Publication on "Electroplating Definitions"

COMMITTEE B-8 on "Electrodeposited Metallic Coatings and Related Finishes" has prepared for publication a series of over 200 definitions relating to electroplating metals. These are the first definitions that have been prepared by the committee covering terms used in Society standards and in the industry.

A specification for multi-layer (duplex) electrodeposited nickel coatings has been prepared to permit standardization of these coatings for use in outdoor surfaces. Two systems are being considered for designating chromium-nickel-copper decorative coatings that will permit labelling to ensure consumer quality. One of these methods will be presented to the Society for publication at the earliest possible time.

Interlaboratory work is continuing to find the best dye for checking the sealing of anodic coatings on aluminium alloys. A specification for anodic film thickness has been completed.

Interlaboratory data on the use of magnetic flux guages to measure electrodeposited film thickness have been reported. These data will provide a basis for revising and enlarging existing thickness test methods in the near future.

Specimens for a programme on decorative coatings for zinc-base die castings are being prepared. Exposure is expected by mid-1961.

The committee will sponsor a symposium on electroforming in the near future. Those interested in participating on this symposium are urged to get in touch with Edward B. Saubestre, technical director, Enthone, Inc., Box 1900, New Haven 8, Conn., U.S.A.

FINISHING
NEWS REVIEW

I.V.E. Annual Conference and Confair, 1961

THE annual conference and Confair of the Institute of Vitreous Enamellers will this year take place at the Hotel Majestic, Harrogate from May 24 to 27. A full technical programme has been arranged, together with visits to works, details of which are given below :

Wednesday, May 24

4.00 p.m.—Conference Office open.

7.00 p.m.—Official Opening of the Conference and CONFAIR 1961, by His Worship, The Mayor of Harrogate, followed by a Reception for all Delegates and Ladies.

Thursday, May 25

9.00 a.m.—Coaches leave for visit to either British Titan Products Co., Ltd., Billingham, Co. Durham, **or** The General Electric Co., Ltd., Mexborough, Yorks.

5.30 p.m.—Coaches return to hotel.

7.30 p.m.—" Edwardian Night." A Dinner and Entertainment.

Friday, May 26

9.30 a.m.—Technical Session " A " —Paper 1- -" Interfacial Reactions." A Sub-Committee Report.

10.30 a.m.—Coffee Break.

10.45 a.m.—Paper 2—" Electroluminescent Enamels "—P. W. Ranby. (Thorn Electrical Industries Ltd.).

11.45 a.m.—Paper 3—" Enamelling for Architectural Purposes " —D. Mill (Escol Products Ltd.).

1.00 p.m.—Luncheon.

2.15 p.m.—Technical Session "B" —Paper 4— " Conditions and Considerations of the Modern Weekly Wash "—F. Pennock (Thomas Hedley & Co., Ltd.).

3.15 p.m.—Tea Break.

3.30 p.m.—Paper 5—" The Economics of Low Pressure Spraying" —J. Muirhead (Aerograph-De Vilbiss Co., Ltd.).

4.30 p.m.—Paper 6 — " Testing Methods."

7.30 p.m.—Gala Dinner Dance.

Saturday, May 27

CONFERENCE DISPERSES.

* * *

A programme has also been arranged for the Ladies which will include talks on " Choosing Antiques for the Modern Home " and " Conditions and Considerations of the Modern Weekly Wash."

CONGRESS DELEGATES FROM EIGHT COUNTRIES VISIT BERK COATING DIVISION

SCIENTISTS from the United Kingdom, U.S.A., Canada, U.S.S.R., France, Belgium, Sweden and Israel visited the Park Royal Works of the Coating Division of F. W. Berk & Co. Ltd. during the First International Congress on Metallic Corrosion. They were shown one of the largest shot-blasting chambers in Europe (capable of treating the largest of road tankers), the company's extensive facilities for smaller shot-blasting and metal-coating contracts, advanced fluidization and spray techniques for plastic coatings, equipment for the application of Epikote linings, and examples from the Berk range of metal spray pistols, shot-blasting machines, test instrumentation and ancillary equipment.

The illustrations show visitors examining a " Slim Jim " shot-blasting machine and a plastic-coated fan.

METALS DIVISION FOR DEWRANCE

DEWRANCE and Co. Ltd. announce the formation of the Dewrance Metals Division. This will consist of the foundry at Hillington and the special alloys division in London.

The new division will have its own board of management and will be responsible for the production and sales of high quality non-ferrous castings, nickel alloy castings, stainless-steel castings, "Endewrance" hardfacing and high temperature brazing alloys. The production executive is Mr. J. B. Morton at Hillington, and the sales and technical executive is Mr. E. Wallace in London.

BORAX AND BORIC ACID PRICES

BORAX Consolidated Ltd. advise that a further increase in ocean freights is now payable.

It is their intention to hold present prices as long as possible, in spite of this increase in costs. Until further notice the price schedule of February 1, 1961, remains unchanged.

COMMONWEALTH TECHNICAL TRAINING WEEK EXHIBITIONS

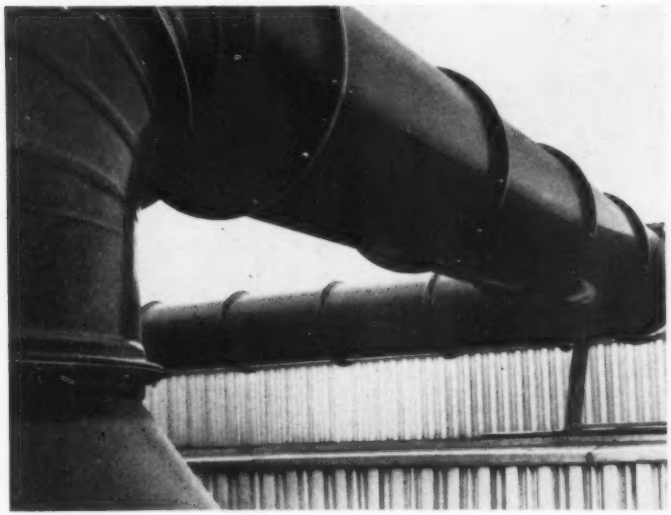
THE exhibition on technical training at the Royal Exchange in the City of London is one of the central activities of Commonwealth Technical Training Week.

This exhibition, from May 29 to June 3, will include a unique display provided by the City Livery Companies in which examples of superb craftsmanship and items of great historic interest (such as the original silver yard of the Merchant Taylor's Company) will be included.

The Livery Companies' display will form a background to the major part of the exhibition, which is devoted to the importance of vocational training and the wide opportunities presented to the young people of today by industry, commerce and the public service. Also running concurrently with Commonwealth Technical Training Week will be the Industrial Equipment and Services Exhibition in the Princes Hall, Bingley Hall, Birmingham. This exhibition is taking the place of the Safety and Factory Efficiency Exhibition.

PVC COATING OVERCOMES CORROSION PROBLEM

THIS ducting at Courtauld's "Fibro" manufacturing plant has been given an anti-corrosive coating by dipping in PVC. The ducting is part of the degassing plant and carries 5,000 cu. ft. per min. of air saturated with water vapour and containing CH_2 and H_2S. PVC dipping cuts out the handwork involved in rubber coating and allows greater control over the thickness of the coating. Bends and awkward shapes can also be lined seam-free. Dipping on the ducting illustrated was carried out by Plastic Coatings Ltd., Guildford, using paste based on Geon 121 PVC resin.



BRP LAUNCH ATTACK ON WATER-SOLUBLE PAINT MARKET

AT a gathering of representatives of the paint industry at Devonshire House recently, British Resin Paints Ltd. announced a reduction in the price of their Epok A.1700 water-soluble resin. The new price is £177 per ton, which represents a saving of £36 per ton on the old price (£213).

This means that water-based paints can now be made and sold at prices below conventional solvent systems. With water as the thinner literally "on tap," and the elimination of the cost of organic thinners, BRP foresee a large demand from industrial paint users for water-based paints.

NEW COMPANIES

"Ltd" is understood, also "Private Co." Figures = Capital, Names = Directors, all unless otherwise indicated.

J. Marshall and Sons (Ripley) Shell House, London Road, Leicester. March 15. £6,000. To carry on the bus. of galvanizers, hollow-ware manufacturers, sheet-metal workers, etc. Jas. S. Harrison, Mrs. Mary E. Harrison, Mrs. Edna A. Harrison.

A. L. Hann, Island Farm Avenue, West Molesey, Surrey. March 23. £1,000. To take over bus. of electroplaters, stove enamellers, etc., carried on as "A. S. Hann & Co" at West Molesey, etc. Albert S. Hann, Mrs. Alice V. Hann, David J. Hann, Geoffrey A. Hann, Robert S. Hann.

H. King (Worcester). March 23. £200. To carry on bus. of engineers, manufacturers and finishers of goods in metal, wood, plastic, etc. Wm. H. Watts, 45 Oakleigh Avenue, Hallow, Worcester; John L. King, Horace S. King, Robert H. Aitken.

Atkins Laboratories, 10-11, Fetter Lane, E.C.4. March 30. £100. To enter into an agreement with W. S. Atkins and Partners Ltd. and to carry on bus. of non-destructive testing and inspection of all kinds of electronic, ultrasonic, mechanical and visual testing equipment, etc. Directors not named.

Central Enamelling, 42 Clement Street Parade, Birmingham. April 4. £100. Russell Assing, Fredk. J. Meredith.

G. P. H. Metal Processing, Room 5, 12 Coleman Street, E.C.2. April 5. £500. To carry on bus. of electroplaters, etc. Leonard S. Giness, Eric A. Rowling.

From the Register compiled by Jordan & Sons Ltd. 16 Chancery Lane, London, W.C.2.

KANIGEN PROCESS SUB-LICENCED

ALBRIGHT and Wilson (Mfg.) Ltd. announce that they have granted to Fescol Ltd. a sub-licence for the operation of the Kanigen electroless nickel-plating process. Fescol Ltd. are planning to erect the necessary plant at their works at Brownshill, Staffs.

Kanigen chemical nickel plate is a nickel-phosphorus alloy containing about 8 per cent. phosphorus. It has extremely low porosity and is hard (1000 V.P.N. after heat treatment) and corrosion and wear-resistant. On ferrous materials the plate prevents contamination of liquids by iron from pumps, pipework and containers. Expensive alloys can often be replaced by Kanigen-plated steel or aluminium.

Kanigen plate has already been proved to be an ideal method of plating for many aircraft applications because of the way in which plating can follow, more precisely than any other known method, the contours of the most complicated cast and machines parts. The plating solution deposits a continuous and completely uniform plate on the most complex components.

Kanigen is recognized both by the Ministry of Aviation and by the Air Registration Board by whom it has been approved under DTD 900/4505 and AI 5112/57 respectively.

CORROSION PREVENTION

A SPECIAL exhibition on metallic corrosion and its prevention was held recently at The Science Museum, South Kensington, London, S.W.7.

This collection of exhibits relating to corrosion and preventive measures was assembled by the Corrosion Group of the Society of Chemical Industry to mark the First International Congress on Metallic Corrosion, held in April.

It has been estimated that the yearly cost of corrosion to Great Britain alone is at least £200 million ; the subject is, therefore, of great national economic importance and of direct interest to the layman. For this reason although the exhibition was of particular interest to the delegates to the Congress, it was designed to be intelligible and interesting to the non-specialists who formed the majority of visitors to the Museum. It set to answer in simple terms the questions : What is Corrosion ? How and when does it take place ? What can be done to prevent it ?

BLUNDELL, SPENCE CELEBRATE 150th ANNIVERSARY

HIGHLIGHT of Blundell, Spence and Co. Ltd's 150th anniversary celebrations occurred recently when two murals commissioned from Anna Zinkeisen were unveiled at the company's head office, York House, Queen Square, London, W.C.1. The ceremony was performed by Mrs. E. B. Calvert, wife of the company's chairman and managing director. This was followed by a short speech by Miss Zinkeisen.

Mr. E. B. Calvert, chairman and managing director, explained that the purpose of the murals was to record in a tangible way the company's debt to the past. It also fulfilled what he considered to be a new responsibility of business today — patronage of the arts. He added that it was appropriate for a company which founded its fortunes on paint to be commemorated in the same medium. The murals would remain in place " for all time " — or until the company expanded to the extent of requiring larger premises, when they would be moved.

LABORATORY APPARATUS ON SHOW

A COMPREHENSIVE cross section of laboratory instruments and furniture for every type of scientific research, development and industrial laboratory, manufactured or stocked by the Griffin and George Group of Companies, Alperton, Middlesex, will be shown at the Laboratory Apparatus and Materials Exhibition, Royal Horticultural Halls, London, from June 19-22, 1961.

Among the many instruments to be shown for the first time at this Exhibition will be:—

The Griffin "D-6" Chromatograph, the first Chromatograph ever to use, as detector, the Martin gas density balance.

The Griffin Flame-Ionisation Chromatograph designed as an economic apparatus for analysis of hydrocarbons.

Shore Scleroscopes used throughout the world for testing of the hardness of metals.

The Portable Shore Durometers designed for the testing of hardness of rubber, and similar materials.

The Griffin Courtauld Atomic Models, a new series of 30 light-weight accurately moulded plastics atomic species particularly suitable for the study of the intricate sterochemical problems arising in synthetic and natural high polymers.

The Griffin Oscillating Hotplate (Fisher pattern), a combination of hotplate and oscillating unit which enables the heating and agitation of liquids to be effected simultaneously.

The Griffin-Grundy oven, specially designed as a reliable oven at an inexpensive price. The maximum temperature is 200°C. ± 0.5°C.

SIMON-WALDRON TO EXHIBIT AT INTERPLAS FAIR

FOLLOWING the recent announcement, that Henry Simon Ltd., had concluded a licence agreement with the Midland-Ross Corporation of Cleveland, U.S.A., to manufacture and market its Waldron web processing equipment in Europe under the name Simon-Waldron, Henry Simon announces that its Coating Plant Dept. will be exhibiting Simon-Waldron equipment at the International Plastics Exhibition & Convention at Olympia, London, from June 21 to July 1.

On stand C12, the international buyer will get his first introduction to the full Simon-Waldron range. He will see, in addition to machinery, photographs of equipment for coating by brush, knife, roll or air-blade ; edge guides, trimmers, slitters, embossing calenders and metal strip coating systems. Also on display will be a continuous projection unit showing 16mm. film of web processing equipment. Members of the newly-formed Coating Plant Dept. will be on hand to advise and demonstrate.

I.C.I. AT 13th CHEMICAL ENGINEERING EXHIBITION AND CONGRESS

SHOWING for the first time at Achema, I.C.I. Metals Division will feature the varied uses of I.C.I. titanium in chemical and electrochemical plant. This exceptionally corrosion-resistant material is extensively used for making or lining chemical vessels and for equipment ranging in size and complexity from valves, pumps and anodising jigs to heat exchangers, bleaching plant and gas scrubbing equipment.

Marston Excelsion Ltd., (an I.C.I. subsidiary company), share the Metals Division display. Marston specialize in the fabrication of aluminium, titanium and other non-ferrous metals, stainless-steel, reinforced plastic laminates and synthetic rubbers. Examples on show include a titanium heat exchanger and a titanium-lined steel vessel with solid titanium internals. "Portolite" flexible tanks for the bulk transport of liquids and "Marex" laminated plastic industrial fans will also featured.

WORLD CORROSION EXPERTS VISIT BRITISH LABS

SIXTY experts on fighting metallic corrosion from all over the world, in London recently for the first international conference on the subject, visited the laboratories of the British Non-Ferrous Metals Research Association in Euston Street, London, to see the progress being made by Britain in this field. A party which included two Dutch women specialists, Dr. C. H. de Minjer and Dr. E. M. J. Mulders, is seen in the plating room where they saw the considerable work which BNF is doing in developing accelerated corrosion testing as a means of differentiating between good and bad plating without the necessity for long-term outdoor exposure tests.

BRITISH FIRM TO HANDLE U.S.A. PLATING AND CLEANING CHEMICALS

IN these days of newer and progressive industries it is essential to be unfettered by the previous outmoded thinking which has retarded the development of electroplating in this country. With this in mind PMD Chemicals Ltd. has been formed to exploit the need for a more modern outlook towards the new techniques, new types of component and climatic conditions which continually emerge. As an extension of this policy, plating processes have been, and are being developed which are fully in step with these requirements.

The policy of the company, controlled by Mr. Richard Fairfax Naylor, managing director, and Mr. Edgar Marlow, technical director, will be one of continuous research into, and the production of electroplating processes.

Arrangements have been made to handle the sole distributorship of Lea-Ronal plating processes on behalf of Lea-Ronal Inc. of U.S.A. Processes which include high-speed gold, silver, brass, copper and nickel are entirely new to Europe and will be handled exclusively in this country by PMD Chemicals Ltd. In addition to this range the company will sell Lea polishing compounds and additives, made by Lea Manufacturing Co. of Buxton, Derbyshire. These compounds and compositions are a range specifically developed by Lea Manufacturing Co. of U.S.A. for use with Lea-Ronal processes to attain maximum efficiency in plating.

Other distributorships in American products include one on behalf of The Wyandotte Chemicals Corp ; a complete range of cleaners for the metal finishing industry.

PMD Chemicals will also be marketing an entirely new protective treatment for Aluminium known as "Alchromate." This process has been developed solely by this company and will be sold by them exclusively. The treatment is non-electrolytic and is designed to give full climatic protection to treated parts, with the advantages of simple processing and low installation costs.

In addition to the comprehensive range of high-speed top-quality processes available the accent will be on service, and in this connection Mr. F. W. Batty has been appointed to the sales team.

TECHNICAL *and* INDUSTRIAL APPOINTMENTS

After 21 years service with the Industrial Division of paint manufacturers **Blundell, Spence and Co. Ltd.,** and its predecessors, Mr. J. E. R. Hyson has retired and settled in Spain.

Mr. Hyson joined Vulcan Products Ltd. (which in 1959 became part of the Blundell Industrial Division) in 1940, and developed the company's sales in Bucks, Berks, Oxon, Middlesex and London. Later he was promoted to regional sales manager for the North of England and Scotland. Eventually he returned to London and in latter years was the company's industrial finishes representative for Hants, Sussex, Surrey, Kent, as well as handling special accounts in the London area. The day before he left for Spain, Mr. Hyson was presented with a silver cigarette box.

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Mr. H. W. G. Hignett and Mr. Jean M. Dhavernas have been appointed directors of **The International Nickel Company (Mond) Ltd.**

Mr. Hignett remains managing director of Henry Wiggin and Company, Ltd. Mr. Dhavernas is located in Paris and has been closely concerned for many years with nickel markets on the Continent.

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Mr. Michael J. S. Clapham, who has been chairman of **I.C.I. Metals Division** since January 1960, has been appointed a Director of I.C.I. He is to be an Overseas Director vice Dr. J. S. Gourlay who is to be Group A Director (responsible for Alkali and General Chemicals Divisions).

Mr. Clapham joined I.C.I. Metals Division in 1938 to assist in running the Kynoch Press, of which he became Manager in 1940. In 1942 he was seconded to the Directorate of Tube Alloys (Atomic Energy), Department of Scientific and Industrial Research, to develop the work started in the Kynoch Press on producing barriers for an isotope diffusion plant. In 1944 he was appointed personnel manager and a year later personnel director of I.C.I. Metals Division. He became a joint managing director of the Division in 1952.

Mr. Clapham is a director of Pyrotenax Ltd., Yorkshire Imperial Metals Ltd. and Imperial Aluminium Co. Ltd. He is chairman of the Non-Ferrous Wrought Metals Export Group and a Vice-President of the British Non-Ferrous Metals Federation.

Mr. Harold Smith, who has been chairman of **I.C.I. General Chemicals Division** for the past two years, has been appointed a Director of I.C.I. He will take over as technical director from Dr. Richard Beeching when Dr. Beeching becomes chairman of the new British Transport Board.

Joining I.C.I. in 1929, he went to the research department of the Dyestuffs Division for 10 years and then joined the production department, becoming assistant works manager of the Division's Huddersfield Works in 1943. In 1950 he was appointed head of the Division's production department, becoming production director in 1952 and joint managing director in 1955. He joined the General Chemicals Division of the company as joint managing director in March 1957 and was made chairman of that Division in February, 1959.

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Mr. Bert Oade has been appointed North Western area sales representative for **Silvercrown Ltd.**

As area representative, Mr. Oade will work in co-operation with the Silvercrown Depot at Trafford Park (Tel. : Trafford Park 0401). His address is 19 Raglan Road, Stretford, nr. Manchester (Tel. : LONgford 4003).

* * *

Darchem Engineering Ltd. (a member of the Darlington Chemicals Group), announces three new appointments :—

Mr. A. B. Miles, becomes chief engineer, after six years with the company. Mr. F. Meadows, chief draughtsman. He joined the company in 1955. Mr. D. A. Rowlett, M.Sc. (Eng.) has been appointed manager of the Rostenit (stainless steel lining process) Division.

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Arthur D. Gaskin, one of the founders of the company, has retired as vice-president of **Alert Supply Co., Los Angeles.** Mr. Gaskin will continue his association with the company as a director and in an advisory capacity.

Also announced is the election of Paul A. Waalkes as a director and a vice president. Mr. Waalkes will continue to be sales manager of Alert Supply Company.

Alert Supply Company is a wholly-owned subsidiary of Hanson-Van Winkle-Munning Company, Matawan, N.J.

Laporte Industries Ltd. announce that Mr. G. Hickson and Dr. F. S. Spring, F.R.S. have been appointed directors of Howards and Sons, Ltd.

Laporte also announce the retirement at the end of August of Mr. T. Anness, general manager of **A. W. Brook Ltd.,** their midlands sales organization.

Mr. Anness will be succeeded by Mr. M. H. Akeroyd, who will combine the responsibilities of this position with those of his present appointment of midland area sales manager.

* * *

Mr. E. B. Bishop has been appointed secretary of **Metal Cleaning Ltd.,** (a member of the Castrol Group of Companies). He succeeds Mr. G. J. B. Williams who will now concentrate on the company's reorganization and sales development. Both Mr. Bishop and Mr. Williams are directors of Metal Cleaning Ltd.

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The Lord President of the Council and Minister for Science, Lord Hailsham, has appointed Sir Harold Roxbee Cox as Chairman of the **Council for Scientific and Industrial Research** for five years from October 1, 1961. He will succeed Sir Harry Jephcott, who has been Chairman of the Council since its formation under the DSIR Act of 1956, and who will complete his term of office in September. Sir Harold has been a member of the Council since 1957.

Sir Harold Roxbee Cox, D.Sc., Ph.D., D.I.C., M.I.Mech.E., F.R.Ae.S., F.Inst.F., F.I.Ae.S., who is 58, is an engineer by profession and has spent over twenty years in the government service. In this time he has done pioneer work on jet propulsion, gas turbines and problems of fuel and power. After six years as chief scientist of the Ministry of Fuel and Power, he left government service in 1954 for industry, and in January of this year was appointed Chairman of the Metal Box Company Limited. He is active in the field of higher technological education and is Chairman of the National Council for Technological Awards.

* * *

The Rt. Hon. Lord Clitheroe, P.C., has been appointed a Vice-Chairman of **Tube Investments Ltd.**

Sir Ben Lockspeiser, K.C.B., F.R.S., and Sir Francis de Guingand, K.B.E., C.B., D.S.O., have resigned from the Board. Sir Francis is returning to the Union where he will continue to be in charge of TI's interests in Southern Africa.

Dr. J. M. Kay, M.A., Ph.D. has been appointed director of research and development from July 1, 1961.

OVERHEAD HANDLING IN CAR BUMPER PRODUCTION

A NEW handling system has been introduced by Wilmot Breeden Ltd. in the plating section of their car bumper works at Amington Road, Birmingham. The semi-automatic system is used in conjunction with a British MonoRail overhead runway and hoist installation, on which the bumpers, loaded on jigs in batches of up to twenty, pass through all the plating stages on a continuous cycle, without being removed from the system. Throughout the series of operations, each loaded jig is under the individual control of process operators.

On arrival at the plating shop, bumpers are assembled on jigs to which they remain attached until plating is completed, and then immersed in a series of preparations and plating vats according to a strict time schedule. The need for accurate timing and maximum output makes it essential that the raising, lowering and transferring should be carried out speedily and smoothly.

The British MonoRail system which has been installed ensures this by providing a full circuit, with separate "out" and "return" lines of overhead dual runways some 152 ft. long, parallel with each other and connected at each end by a transfer crane section. Independent powered hoist carriers, with one-ton hoists attached, are suspended between the two rails of each runway. Pendant controls on each hoist carrier control the raising and lowering of the hoist, and the motion of the hoist carriers along the runways.

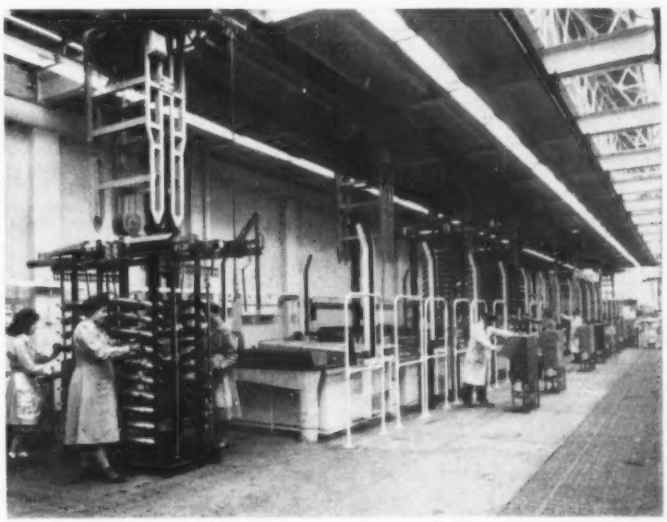
This installation permits a fully continuous handling system to be operated in the plating shop. Hoist carriers on the transfer section at the incoming end of the shop pick up loaded jigs, and are then brought into position to interlock with the plating line runway. They carry the loaded jigs along this line, stopping, raising and lowering at each position under the control of process operators, in accordance with the plating schedule. At the end of the plating line, the jigs are lowered at an unloading station, where the bumpers are removed and the hoist carriers, with empty jigs attached, are run on to the other transfer section, interlocked on to the return line, and taken back to the start of the line, where the empty jig is detached and a filled one is picked up.

Power for the hoist carriers is provided on the runways by a set of conductor bars attached to one of the two rails and picked up by each carrier through shoes which run along these conductors. "Kant-Shock," a patented British MonoRail insulated sleeving is fitted to prevent accidental contact by maintenance staff. Motion of the carriers along the runways is provided by an electric motor which drives a rubber-tyred wheel in contact with the underside of both of the runway rails.

Along the plating line, the speed of travel is 100 ft. per min., the highest speed which will allow the operators close control of the position of the jigs; on the return line, where there are no intricate movements, the travel speed is increased to 200 ft. per min.

The entire handling system is located in the space above working height leaving the floor free and allowing maximum visibility and access. A special feature of the British MonoRail system is the very small headroom it requires, so that in this particular installation, although the plating shop is not unusually high, the jigs can be lifted well clear of the tanks during the plating process.

Since this installation was brought into use, Wilmot Breeden Ltd. have ordered from British MonoRail Ltd. (Wakefield Road, Brighouse, Yorks.) a similar scheme for another plating works in Birmingham.



The overhead runway in the plating section

B.I.T.A. AWARD FOR SENIOR MECHANICAL HANDLING ENGINEER

THE British Industrial Truck Association continues to foster higher technical standards in materials handling—one of the most important branches of engineering and one of the few remaining avenues for considerable saving of production costs, thus leading to more competitive prices for exports. One of the ways the Association does this is by offering an annual scholarship to enable a selected person to attend a course on materials handling at an advanced level.

The John Morris Memorial Award for 1961 has been won by Mr. William Hollick, A.M.I.Mech.E., senior engineer advising on mechanical handling equipment at Unilever Ltd. for his paper on "The Design of Warehouse and Storage Areas to allow Efficient Handling by Industrial Trucks."

As a result of this Award, Mr. Hollick will attend the 8th Annual Material Handling Course to be held at Lake Placid, New York, from June 18 to 30, 1961. This Course, organized by Mr. James R. Bright, director of the Industrial Management Centre, deals with the theory and practice of materials handling at an advanced level and is particularly aimed at senior engineers engaged in developing new handling systems.

On his return to Britain, Mr. Hollick will, during the following year, lecture on his experiences in the U.S.A.

Trade and Technical Publications

The terms being defined by ASTM Committee D-26 on Halogenated Organic Solvents include safety solvents, toxicity, dermatitis, occupational dermatosis, health hazards, combustibility, flammability, etc. In the solvents industry, a major objective is safe use of cleaning solvents. This means minimizing both toxicity and flammability hazards. The committee will assist the solvent-using industries in the safe handling of solvents by publication of a manual on vapour degreasing which is expected within the year. The manual will cover the major considerations involving vapour degreasing equipment, the handling and use of solvents, and general aspects of vapour degreasing. The manual is being prepared by a balanced group of equipment and solvent producers and users.

In the missile industry there are problems in cleaning out empty fuel systems, particularly those which contained liquid oxygen. The solvents used for this purpose must be exceptionally free of impurities or suspended particles, and the committee is developing a specification for trichloroethylene for this type of application.

Elsewhere in the committee, other uses of solvents are being considered, particularly cold cleaning. One group is working toward a manual on cold cleaning which will cover methods of use—that is, spray, dip, wipe, ultrasonics; end-use applications, including the substrate materials being cleaned; and types of solvents and their physical and chemical properties. The manual will also set conditions of use from a safety point of view including problems of flammability and toxicity.

* * *

Selectrons, Ltd., 520 Fifth Avenue, New York 36, N.Y., U.S.A., announce a four-page booklet, available free on request, listing varied industrial uses and advantages of a new, high-speed selective plating process. Typical engineering applications in the electronics, aircraft and missile, marine, machine tool, and gravure industries are included. The booklet also contains a chart indicating deposition rates, metal concentrations, and recommended current densities.

The Selectron process is a means of plating selected areas of a component without having to immerse the entire object in electrolyte. Connected to a portable power pack by a cable, the component acts as the cathode. A second cable is fitted with a stylus to hold a graphite anode wrapped in absorbent cotton. After the cotton is saturated with the proper electrolyte, the stylus is passed back and forth across the area to be plated until the desired thickness of metal has been built up.

Because electroplating is confined to the area in contact with the stylus, specific advantages result: (1) large tanks filled with costly electrolyte are no longer necessary; (2) extensive masking is avoided; and (3) any piece of equipment can be partially plated without disassembly and reassembly.

* * *

The seventeen abstracts in the Electrodeposition section of the February issue of "Nickel Bulletin" published by The International Nickel Company (Mond) Limited reflect, *inter alia*, the considerable amount of work which is being carried out to improve the corrosion-resistance conferred by nickel/chromium coatings, and are followed by items covering literature on non-ferrous alloys, nickel-iron alloys (including a new glass-to-metal-sealing alloy) and the production, heat-treatment and welding of nickel-containing cast irons. The properties and fabrication of high-strength constructional steels are receiving considerable attention, and due reference is made in the Bulletin to thirteen recent papers of interest in this respect.

The section concerned with heat- and corrosion-resisting materials is the largest of the issue, the literature abstracted ranging in content from the mechanical properties and fabrication of heat-resisting stainless steels and high-temperature alloys, to materials suitable for handling liquid gases, studies of passivity in stainless steels, and the resistance of nickel-containing alloys and steels to specific corrosive media.

The latest issue of another Mond publication—"Inco-Mond Magazine"—has increased its page size to the continental pattern 21 x 27 cms. ($8\frac{1}{4}$ x $10\frac{5}{8}$ ins.) and also adopted a modern easy-to-read layout. This page size is already in use for the foreign-language editions of the magazine which appear in French, German and Italian and are widely circulated on the Continent and elsewhere.

This new issue of "Inco-Mond Magazine" includes many articles on the diverse uses of nickel-containing materials, and these and many other articles make up the first issue of the new-style magazine—obtainable free on request from Publicity Department, The International Nickel Company (Mond) Limited, Thames House, Millbank, London, S.W.1.

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Since the introduction of aluminium to the building and shopfitting industry in 1955 by Ajax Aluminium Ltd., they have published a series of catalogues and leaflets illustrating their polished and anodized mouldings for showroom, office and shop windows, shop office and showroom doors and materials for encasing columns, pilasters and fascias, and the series published recently including Entrance Catalogue E.6, Shopfront Section Catalogue S.6 and Estimating and Stock Section Price Lists No. 10 and 11 include their latest sections and provide all technical and other information for estimating the cost of an aluminium entrance or shopfront.

The door catalogue E.6, illustrates the complete range of standard doors in a condensed form while the Shopfront Section Catalogue S.6, is intended for the use and ready reference of the Architect, estimator, draughtsman or setter-out.

Sets of technical data, catalogues, price lists etc. are available on request from Ajax Aluminium Ltd., Lower Sydenham, S.E.26.

* * *

"Piped Heat," a news sheet published by the North Western Gas Board, 60 Whitworth Street, Manchester, 1, which reports new uses of town gas by industry, devotes one of the articles in its current issue to a new type of vitreous enamelling furnace heated by a system of hermetically-sealed looped tubes within which hot gases are circulated at high velocity. By this system uniformity of temperature and freedom from contamination of by-products of combustion within the furnace are ensured.

The publication contains three other reports of interest to industrialists—all in non-technical language.

CHANGE OF NAME

AVIATION Developments Ltd. have changed their name to Avdel Limited. Their address remains Welwyn Garden City, Hertfordshire, but the Telephone Number has been changed to Welwyn Garden 28161.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

Pickling Plant

THE Bäuml system de-oxidizing and pickling plant which is now available from Foundry Suppliers Ltd., 25a, Cockspur Street, London, S.W.1., is shown in Fig. 1.

The equipment allows completely free working in the pickling and washing vats. The movement of the pickling fluid is not interfered with by internal supports or other parts.

The fresh water supply is used first for the cleaning process and second, for the intermediate washing and cooling of the pickling vat, so that the quantity of water used is reduced to a minimum. The installation is also as economical as possible in the use of chemicals for the purification of the exhaust air.

The nitrous gases or evaporated acids which occur in the pickling process are drawn off efficiently immediately under the acid vats, and no damage to health etc. can occur. The exhaust air is completely purified and neutralized.

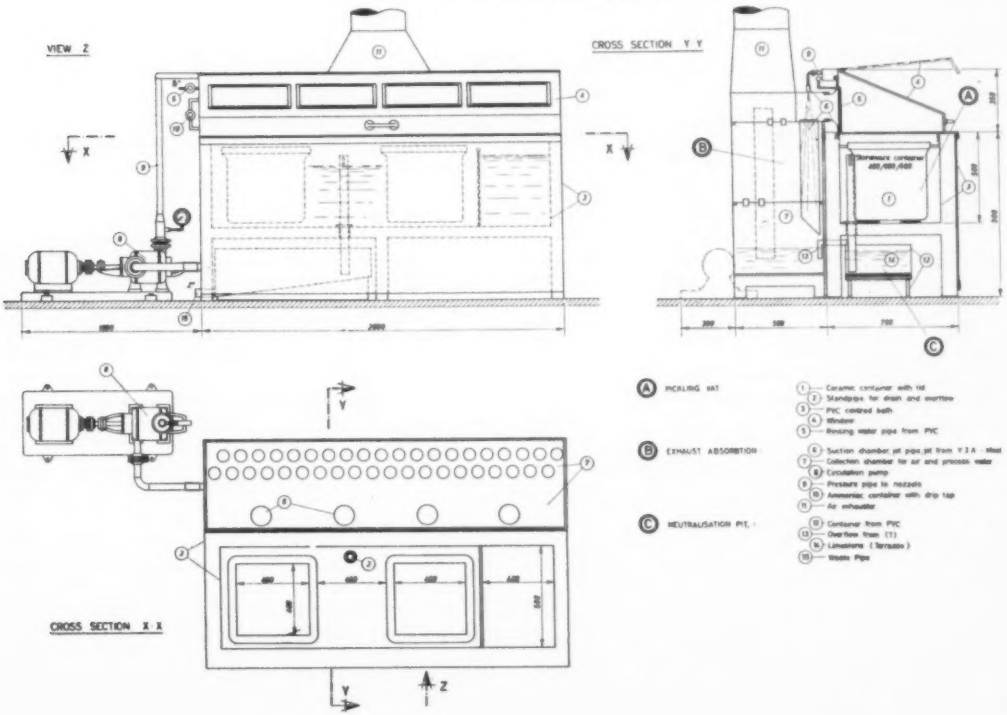
All parts of installation which come into contact with acid water or acid vapours are made from acid-resistant PVC material and have a practically unlimited working life.

The complete equipment exists of three parts :

(a) Pickling and washing vats
(b) Exhaust and neutralization chamber
(c) Waste-water neutralization.

The process water in the bottom part of chamber (7) is made alkaline through the addition of 1/2 per cent NaOH. The fume scrubbing liquid is drawn in and brought up to a pressure of about 86 lb. per sq. in. by the centrifugal pump (8). The washing water is led at this pressure to the nozzles, which produce a vacuum in the suction

Fig. 1. De-oxidizing and pickling plant.



chamber (6). The acid vapour is thereby drawn out of the space over the pickling vat with a velocity of approximately 1 ft. per sec.

An abundant foam is produced over the absorbtion solution, by means of the addition of a surface-active substance to the solution, which itself is not sensitive to the electrolyte. By these means there is such a large increase of the effective contact surface, that the remnants of the harmful gases are extracted and completely cleaned air is exhausted through (11).

The washing water, which is brought in through pipe (5) reaches the cleaning vat first and from there through an overflow the bath (3) where it provides intermediate cleaning and cooling for the ceramic container (1). The used water goes through the standpipe (2) into the neutralization container (12) and flows through the waste pipe (15) into the drain with a pH-value of approx. 7.0.

For complete absorbtion of nitrous gases an addition of ammoniac in small quantities to the fume scraping water is necessary. This is led into the container (10) in the form of a concentrated fluid solution (sal ammoniac) and is fed to the washing water by means of an adjustable drip tap.

The circulation pump (8) and the neutralization container (12) can be placed right or left of the plant.

Approximately 36,000 cu.ft. of air is drawn from the room by the exhaust nozzles per hour. It is therefore necessary to have suitable ventilation for the room to avoid too much cooling effect in winter for the attendants.

Running costs consist of : electricity consumption of the circulating pump ; fresh water consumption for rinsing and cleaning ; consumption of chemicals for the neutralization process ; supervision.

The water consumption is determined by the periods of use of the equipment and by the kind of pickling material. It is therefore not possible to reckon the water consumption in advance.

In general the following figures apply to one week's service at the rate of 8 hours per day :

Pump motor load	2-3 kW
Electrical consumption	80 kWh
Consumption of 50% natron lye	5 kg
Consumption of concentrated ammonia	2.5 gal.
Attendance time	1 hour

Telescopic Elevator Truck

A NEW mobile telescopic elevator in the "Vertolifter" range (Fig 2) has been introduced by Powell and Co., Burry Port, Carms., for high stacking of light loads at fast speed. Two standard heights of lift are available, viz., 120 in. or 148 in., and loads up to 350 lb. can be elevated at a speed of 26 ft. per min. Twin forks are 24 in. long and a detachable platform can be fitted if required.

Lowered heights are only 74½ in. or 88½ in. respectively, hence the elevator can negotiate standard doorways. It is also useful for basements with low headroom where loads have to be lifted to first floor level through hatches.

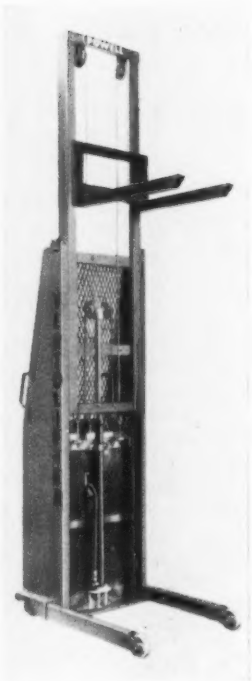


Fig. 2.

Telescopic elevator truck

The hydraulic ram is powered by battery or by three-phase or single-phase mains electricity. A hand-operated variable-speed release valve permits safe controlled lowering.

The motor, pump, etc., are shrouded by a removable one-piece sheet steel cover.

Semi-matt Primer-Undercoat

BLUNDELL, Spence and Co. Ltd., (Industrial Division) have developed a semi-matt primer-undercoat for use in their one-coat Glossex transport finishing system.

Glossex primer-undercoat is for brush or spray application upon the same surfaces as the company's primer-surfacer. Some flatting is required, depending on the quality of finish desired. It can be used either as a primer-undercoat or as an undercoat over a primer, and is suitable for use under hot sprayed lacquer.

Glossex primer-undercoat will eventually replace the company's coach undercoat. But it is stressed that it will be only an alternative to Glossex primer-surfacer, which will be continued for the many who prefer it.

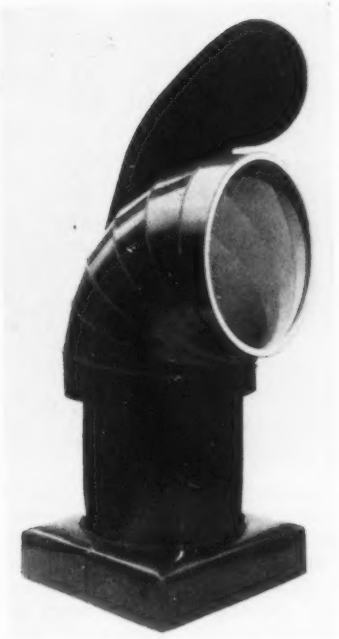
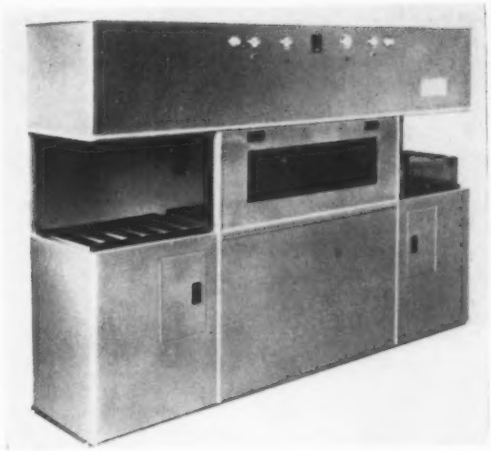


Fig. 3 (left) P.V.C. wind-operated cowl

Fig. 4 (right) Automated industrial cleaning line



P.V.C. Wind Operated Directional Cowls

LATEST from the range of " Turbro " fume removal equipment is the wind-operated directional cowl manufactured from rigid unplasticised P.V.C. (Fig. 3) Available in a wide variety of standard sizes or manufactured to customers' requirements, " Turbro " directional cowls are suitable for chemical works and factories where corrosive fumes and gasses are encountered.

The cowl is finely balanced and rotates freely in a specially protected bearing housing attached to the fixed portion of the duct, and a dual locking device ensures that while the cowl can easily be removed, it cannot be blown off during gales or high winds.

Further information can be obtained from Turner and Brown Ltd., Davenport Works, Davenport Street, Bolton.

Automated Cleaning

FIG. 4 shows a standard CT. 30/A automated industrial cleaning line employing two tanks and using " CT " air-operated agitation and platform lift units ; this equipment is manufactured by Revel Engineering Co. Ltd., Hayes Road, Southall, Middlesex. This model has a capacity of 30 gal. liquid in each tank and a load capacity of 90 lb. A larger model (CT. 60/A) has a liquid capacity of 60 gal. The two tanks are mounted on one base frame, suitably clad, to form one unit. A canopy-type hood extends the whole length of the unit and can be connected to suitable ducting.

With this installation baskets of work are fed to the machine *via* roller track and then transferred, stage-by-stage, by means of an overload travelling arm, to the unload position.

The layout illustrated is a two-stage design and variations are available incorporating up to seven immersion stages, handling loads up to 1,200 lb. per basket at 80 lb. per sq. in.

Operation is by compressed air at 80 lb. per sq. in. and electric process timer. All air components and cylinders are mounted clear of solutions ; only the platform lift arm is actually in the solution. A special arrangement of the air control ensures that each operation is completed before the work is moved to the next stage. Heating is by thermostatically-controlled, steel-sheathed, electric immersion heaters.

Synthetic Enamel

A NEW " one-hour " synthetic enamel has been produced by Teal and Holmes Ltd., Bedford Street, Hull, Yorks. Marketed under the trade name " Impervious " this new paint is supplied in both brushing and spraying qualities in a wide range of colours and gives good coverage. Dust dry in approximately 15 minutes and hard dry in an hour, it provides an economical, full gloss, tough and flexible film with excellent adhesion, particularly to aluminium sheet without previous priming. Particularly suitable for application on metal, it has already been exhaustively tested on caravan exteriors, and may be used for agricultural machinery, vehicle bodies, industrial trucks and machinery and metal constructions.

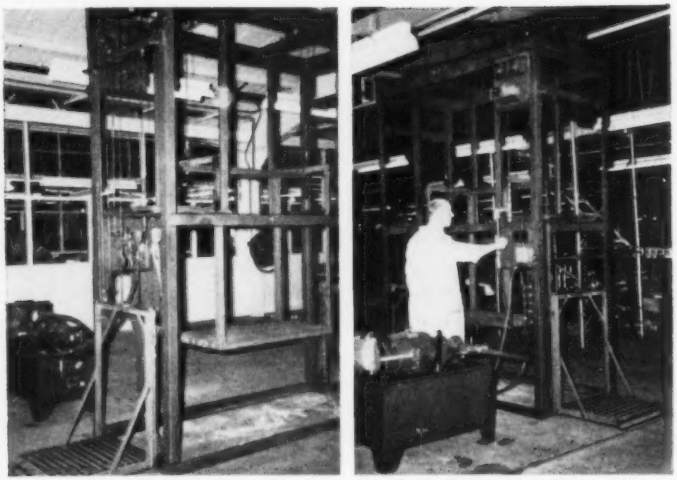


Fig. 5.
Automatic loading and dipping equipment.

Automatic Loading and Dipping for Batch Process Finishing Lines

THERE are many instances in industry where a heterogeneous batch of components must be passed through the finishing sequence prior to spray painting. The semi-automatic loader shown in Fig. 5 is being marketed through R. and D. Industrial Services Ltd., 186 Oatlands Drive, Weybridge, Surrey, and consists essentially of a loading platform of which the model shown will take a load up to about seven cwt. This is raised and the load passed to a centre platform which is above the level of the dipping tank. The operator from a control panel then causes the load to descend into the process tank so that it remains there for a period which can be pre-set, after which it is withdrawn and proceeds to the unloading platform on the other side of the equipment.

The model shown operates on a hydraulic principle but can also be operated mechanically where hydraulic services are not normally available. It was purpose designed for immersion in trichlorethylene but obviously is adaptable to derusting process lines, such as phosphating. Where there are a number of tanks in sequence the batch of work can be placed on the loading platform and transferred to the centre platform for immersion in the first tank in the normal way. After a pre-set time interval it is raised and transferred by rails or rollers to the next tank where a similar elevating platform takes it to the next processing stage. Thus, by increasing the number of centre units it is possible to introduce the principle of the equipment to a complete processing line with, of course, final unloading.

The advantages are that a mixed batch of components can be treated as well as, say, a single casting up to the load limit of the machine and then one man, with minimum effort, can superintend the batch through the whole sequence of operations so that the paint spraying line receives a constant flow of work. In the process of manual hoists the operative has, of course, to progress the work through each tank and assess the time for which the work is immersed in these tanks.

This semi-automatic batch loading equipment for the finishing industries has many outlets in the medium sized firm. In fact, it can often pay for itself within twelve months, simply by reduced man-handling of the components being processed.

Spray Booth

ALFRED Bullows and Sons Ltd., Long Street, Walsall, announce the introduction of a new version of their Nopump spray booth.

This is a self-contained 'packaged' unit which can be used virtually anywhere and is the first booth of this type to be offered in this country. Being a Nopump spray booth, it embodies the revolutionary features inherent in this design *i.e.* no circulating pump, filters, pipes or nozzles, complete reliability, infrequent maintenance, reduced space requirement etc. The new booth is of monoform construction in 16-s.w.g. sheet metal and is 5 ft. wide, 4 ft. overall depth, and has a height of 9 ft. 2 in. to the fan. It is available as a standard bench-type unit which can be converted to a full-depth type quickly and easily by the use of a conversion kit.

A further advantage claimed is that the power consumption is less than that of a conventional water-wash spray booth of the same size. The fan is driven by a 3-h.p. motor and the extract rate is 3,500 cu. ft. per min. at 3½ in. w.g.

(*Continued in Advert p.* 29)

Chrome Pigment

SUPRA Primrose Chrome 6GS is a new greenish-yellow lead chrome pigment introduced by I.C.I. Dyestuffs Division. It is claimed to have excellent weathering resistance and is therefore of immediate interest for the economical pigmentation of high-quality industrial finishes, in which it shows neither bleeding nor blooming and has very good heat fastness under the normal processing conditions. The makers say it surpasses all other primrose chromes, including the so-called " light-fast " types, in its outstanding resistance to darkening in full shades on exterior exposure, and represents a further advance over the Pure Primrose Chrome L6GS introduced by the Dyestuffs Division four years ago.

Supra Primrose Chrome 6GS is expected to find its main value in stoved transport finishes for lorries, vans, buses, etc. and in stoving finishes for petrol tankers, pumps and oil-dispensing equipment, where high light fastness coupled with excellent solvent fastness is required. It will also be of value for finishes for permanent metal signs and prefabricated metal parts for outdoor structures. In common with other chrome pigments, Supra Primrose Chrome 6GS is less durable in reduced shades.

In air-drying media the new pigment shows a similar degree of improvement over existing high-quality primrose chromes, although its performance is not quite at the high level shown in stoving media. It will, however, be of special value in quick-drying finishes using strong solvents, contributing economy combined with high opacity.

In the printing inks field, Supra Primrose Chrome 6GS will be found of principal value for producing opaque roller coating enamels and tin-printing inks, where its high resistance to heat and steam sterilization conditions shows to advantage.

Supra Primrose 6GS will find use in many other fields where opacity, good heat fastness and excellent durability are required.

New Material for Surface Protection

SPICERS Ltd., 19 New Bridge Street, London, E.C.4. announce a new packaging material, " Spi-seal," which is made by coating one side of kraft paper with a special adhesive which sticks only to itself.

This development closely follows the recent successful introduction of self-adhesive Carbion. Both materials are great time-savers, in that they need merely be folded round the part to be packed, the inside surfaces bonding together firmly as soon as they touch. Whereas self-adhesive Carbion, with its permanently resilient double-wave pattern, is designed to provide a cushioning pack, Spi-Seal is intended primarily as a surface protection against scratches, dust and dirt.

The new material is intended for protecting sensitive surfaces during shipment and storage. Tests have shown that the adhesive used is completely neutral and causes neither staining nor discoloration on paints, lacquers and varnishes. Although standard Spi-seal is not claimed to provide complete corrosion protection, it certainly has no corrosive effect and will reduce atmospheric attack by providing a near-impervious envelope.

The material can be used either for hand-packing or, with special-purpose machines, for flow-line packing. It can also be used in most heat-sealing units designed for thermo-plastic film packing, but at a much higher rate, since no heating and sealing dwell are required.

Available in reels up to 45 in. wide, assemblies or machines of any size can be enveloped by joining several pieces by pressing the edges together. Small parts are protected by folding the material onto itself. Spares, accessories and replacement parts can be protected against loss by sealing them into a clearly marked strip of Spi-seal and attaching this to any convenient point.

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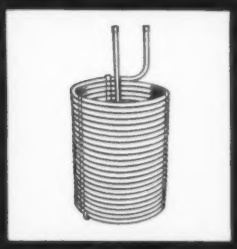

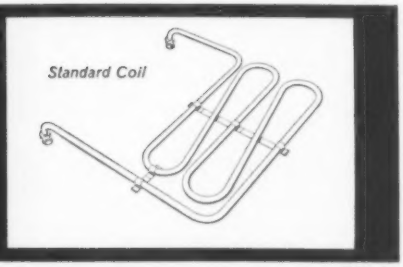

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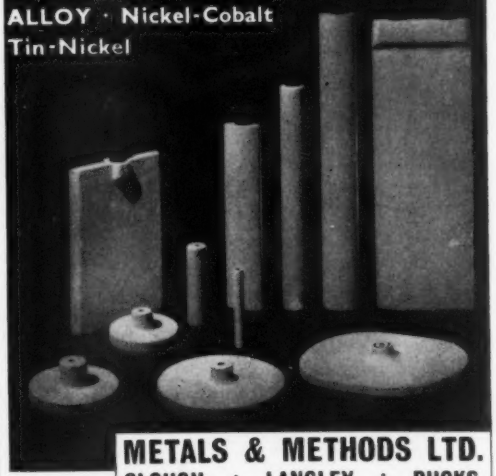

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	Page		Page
Acme-Efco Ltd.	19	Hellerman Ltd.	1
Aerograph DeVilbiss Co. Ltd. The	11 & 22	Hockley Chemical Co. Ltd.	—
Albright & Wilson (Mfg.) Ltd.	14 & 15	Imperial Chemical Industries Ltd.	9
Alkan, M. L., Ltd.	2	Incandescent Heat Co. Ltd.	—
Aluminium Platers (Leeds) Ltd.	—	International Nickel Co. (Mond) Ltd.	33
Anti-Dust Services Ltd.	34	Ionic Plating Co. Ltd.	12
Associated Electrical Industries Ltd.	—	Kemball, Bishop & Co., Ltd.	—
Associated Chemical Companies (Sales) Ltd.	3	Laporte Chemicals Ltd.	—
Atlas Copco (Great Britain) Ltd.	—	Laporte Titanium Ltd.	21
Atlas Plating Works Ltd.	—	Lysaght DeVilbiss Co. Ltd.	4
F. W. Berk & Co. Ltd. (Schori Division)	—	Main Enamel Manufacturing Co. Ltd.	20
Blythe Colour Works Ltd.	—	Marston Excelsior Ltd.	31
Borax & Chemicals Ltd.	—	Metalectric Furnaces Ltd.	16
Borax Consolidated Ltd.	—	Metals & Methods Ltd.	34
British Paints Ltd.	23	Metropolitan-Vickers Electrical Co. Ltd.	—
British Rolling Mills Ltd.	—	Morris, B. O., Ltd.	—
British Titan Products Co. Ltd.	6 & 7	Neil & Spencer Ltd.	36
Canning, W., & Co. Ltd.	5 & 25	Newton Plating Jigs & Insulations Ltd.	24
Carrier Engineering Co. Ltd.	—	Oakey, John & Sons Ltd.	32
Christopherson, C., & Co. Ltd.	34	Permacel Tapes Ltd.	17
R. Cruickshank Ltd.	—	John Preston & Co. Ltd.	—
Dawson Bros. Ltd.	28	Plating-Chemie N.V.	—
Deinert & Co.	8	Pyrene Co. Ltd.	—
Electro Chemical Engineering Co. Ltd.	13	Richard, Thomas & Baldwins (Sales) Ltd.	—
Englehard Industries Ltd.	—	Roto-Finish Ltd.	—
Escol Products Ltd	10	Silvercrown Ltd.	35
Gas Council	38	Sismey & Linforth Ltd.	—
Goodlass Wall & Co. Ltd.	37	Stordy Engineering Ltd.	26
Grauer and Weil Ltd.	—	Stuart, Robert, (London), Ltd	24
Griffiths, A. E. (Smethwick), Ltd.	—	Thermal Syndicate Ltd.	32
Hawley, John, & Co. (Walsall) Ltd.	18	Walterisation Co., Ltd. (The)	—
Hedin Ltd.	—		

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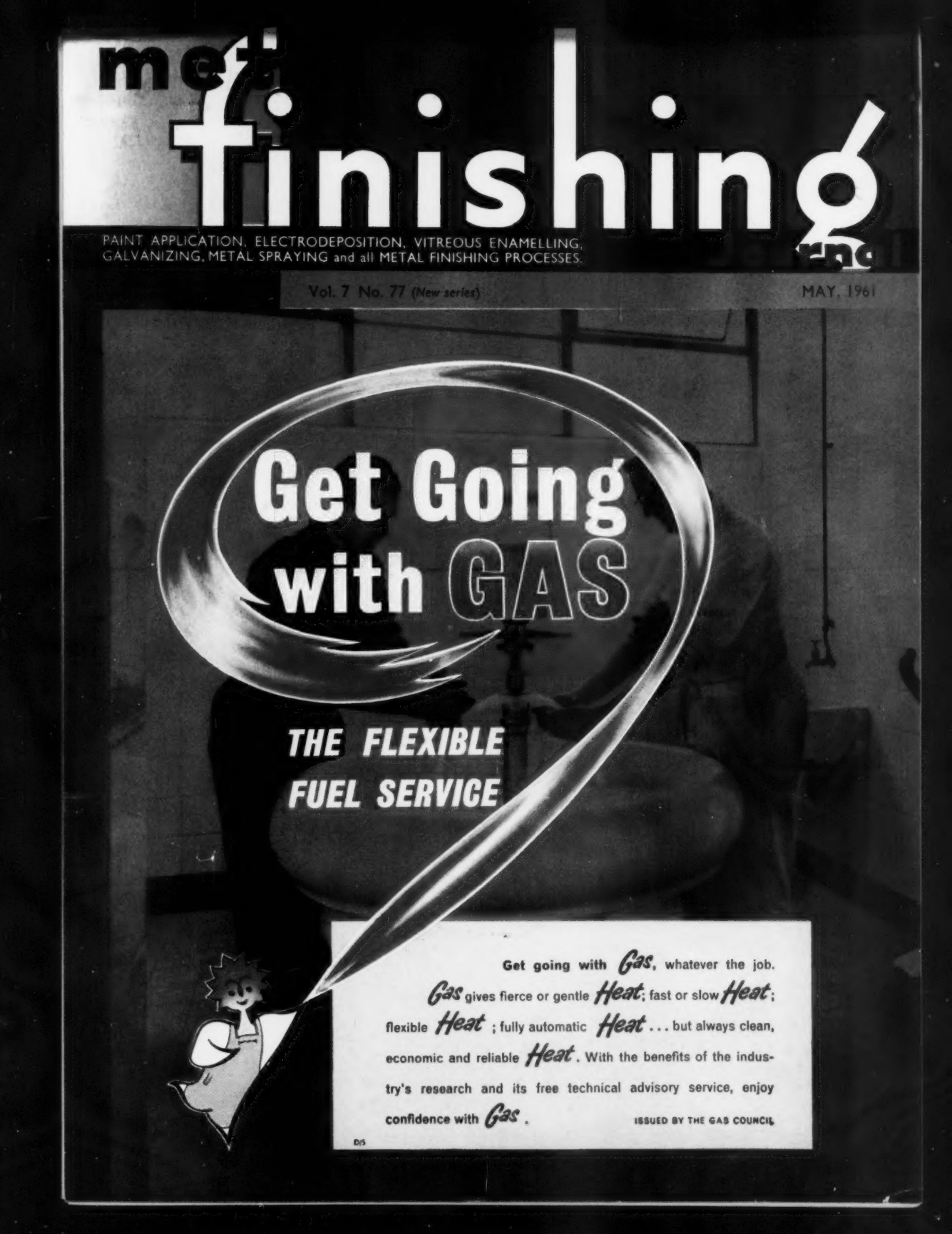
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